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ILIAC-BONE TRANSPLANTATION

Preliminary Observations*

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From a Royal Air Force Hospital

Sir Arthur Keith tells that, in the summer of 1736, John Belchier, a London surgeon, was dining with a friend who was a calico printer. The main dish was a leg of pork and Belchier was surprised to see that the bone was red instead of white. Upon inquiry, he found that his thrifty host fed his pigs madder which had been used in calico dyeing. Belchier guessed that this might be the cause of the red staining, established the truth of his surmise by experiment, and reported his findings to the Royal Society later that year.[3] Thus the experimental study of bone growth and bone repair began.

Keith has also described the work of Duhamel in Paris, who, with John Hunter in London, Syme and Goodsir in Edinburgh, and Ollier in Lyons, continued the study during the next century. The work of Ollier in particular, with his conception of the periosteum as the "maternal tissue" of bone, had great influence on later workers.

In 1878 Macewen removed the whole diaphysis of the humerus of a three-year-old boy, whose osteomyelitis had persisted in spite of several less radical operations. Two years later, the parents brought the boy back to Macewen for amputation of a limb which, though healed, was flail and useless. Macewen opened the arm and put a number of wedges from tibial osteotomies on other patients into the trough where the shaft of the humerus had been. This is the first recorded example of the clinical use of homogenous bone-grafting. The length of the rebuilt humerus was six inches, of which four and one-half inches consisted of grafts. Twenty years later the man had an eleven-inch humerus, three inches shorter than that of the other arm, and was earning his living by manual work.

The result of this operation could not be explained on the basis of Ollier's theory, and from then on arguments about the fate of transplanted bone were added to the controversy which already existed about the mechanism of normal bone growth and bone repair. These arguments and this controversy are still unsettled.

For twenty or more years Albee [1] stated persistently, and with considerable emphasis, that transplanted bone lives and grows in the same way that a transplanted twig grows in the tree into which it is grafted. He used this simile often, and he repeated it and his positive assertion about the survival of cortical bone grafts as late as 1944.[2] On the other hand, some surgeons have held with Leriche and Policard that transplants of cortical

* Read at the meeting of The British Orthopaedic Association, London, June 1, 1945.

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bone always die and are replaced by cells originating in the host bone, and that such transplants form no more than a framework for the ingrowing bone.

Sufficient solid experimental evidence has now accumulated to show that neither of these conceptions of the fate of transplanted bone is correct. The work of Phemister, of Hey Groves, published in an essay which won him the Jacksonian Prize, of Campbell, and of Ghormley and Stuck,[8,9] shows beyond reasonable doubt what happens when the whole thickness of cortical bone is transplanted into another bone. Some of the bone cells of the transplant—those which are near the periosteal or the endosteal surface or in the more accessible Haversian canals—live and grow and form new bone. The cells deep in the dense cortical bone die, and this bone is replaced by new bone which grows either from the surviving cells of the transplant or from the cells of the recipient area. Imbert stated that this process is carried on in all parts but not simultaneously, so that a transplant examined at any moment shows dead bone with empty lacunae, as well as areas of living bone where the lacunae contain nucleated cells. That this is an accurate description of what happens to cortical-bone transplants is now widely accepted.

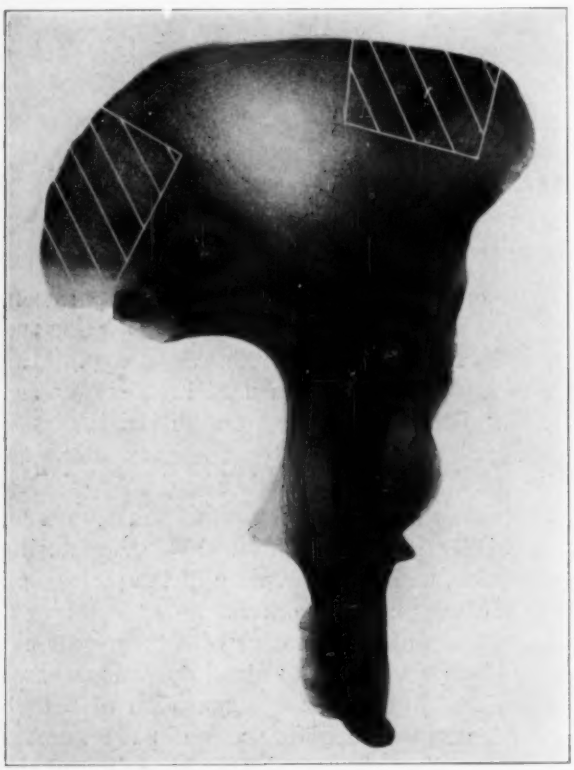

FIG. 1

Roentgenogram of ilium, showing the donor areas.

It therefore follows that, while the strength and stability of cortical bone are often of great mechanical advantage in bone-grafting, this kind of bone may not be the best for the promotion of osteogenesis, for there are areas of bone in which the relative content of bone cells is very much higher than in cortical bone, particularly cortical bone from the tibia. Thus, if mechanical stability can be maintained by other means while the bone is healing and consolidating, it should be possible to make use of the superior osteogenetic properties of cancellous bone.

Experimental evidence supports this hypothesis. Campbell had repeatedly shown that cancellous, or endosteal, bone is the most osteogenetic type of bone graft, and recommended its use when new-bone formation is most necessary, as in areas of greatest stress or in bone grafts for non-union. Gallie asserted that cancellous bone has much greater osteogenetic properties than cortical bone, and Matti produced further experimental evidence of this. Ghormley and Stuck published the results of extensive experiments on dogs, in which they compared the osteogenetic properties of bone transplants from various donor sites. They showed that, of all the known methods of bone transplantation, that which produced the most rapid and sure new-bone formation was the transplantation of cancellous bone chips from the ilium.

This observation is exactly in accord with physiological first principles. A transplanted tissue can continue to live only if it can derive nourishment from the bed into which it is transplanted. It therefore follows that the abundant bone cells in small pieces of cancellous bone, readily accessible to the ingrowing vascular buds, are much more

likely to live and grow in their new surroundings than the scanty cells of dense cortical bone. Compare, for example, how split-skin grafts thrive as free transplants, while grafts of whole-thickness skin need much more careful handling.

The damage done to the tibia, which provides the cortical transplant, must also be considered. Stress fracture of the donor tibia is by no means a rarity, and many patients complain of pain in the donor site long after the grafted area is healed and free of symptoms. Osmond Clarke has more than once said: "The more I see of the results of bone-grafting, the more loath I become to mutilate an intact tibia."

Chips of cancellous bone from the ilium are now frequently used by plastic surgeons in reconstruction of the contour of facial bones, and these surgeons report that clinical rigidity of the reconstructed area is obtained in seven days. The author recently helped a colleague to repair a skull defect, three inches by one inch in size, with iliac chips. When the sutures were removed from the scalp wound at ten days, the bony covering of the defect was already quite hard to finger pressure; indeed, only its irregular surface distinguished it from the surrounding skull. In 1944, Mowlem reported favorably to the Royal Society of Medicine on the use of cancellous chip grafts for the restoration of defects of bone, including the long bones.

The cases described are examples of the use of iliac bone in the bridging of bone defects, and in arthrodesing various joints. These examples, however, by no means exhaust the possible applications of the method.

FIG. 2-A

FIG. 2-B

Case 1. Fusion of spine three months after operation.

OPERATIVE TECHNIQUE

Figure 1 shows that the two accessible areas in the ilium, where cancellous bone is most abundant, are: first, below the crest, just behind the anterior superior iliac spine; and, second, the posterior aspect of the ilium in the region of the posterior superior iliac

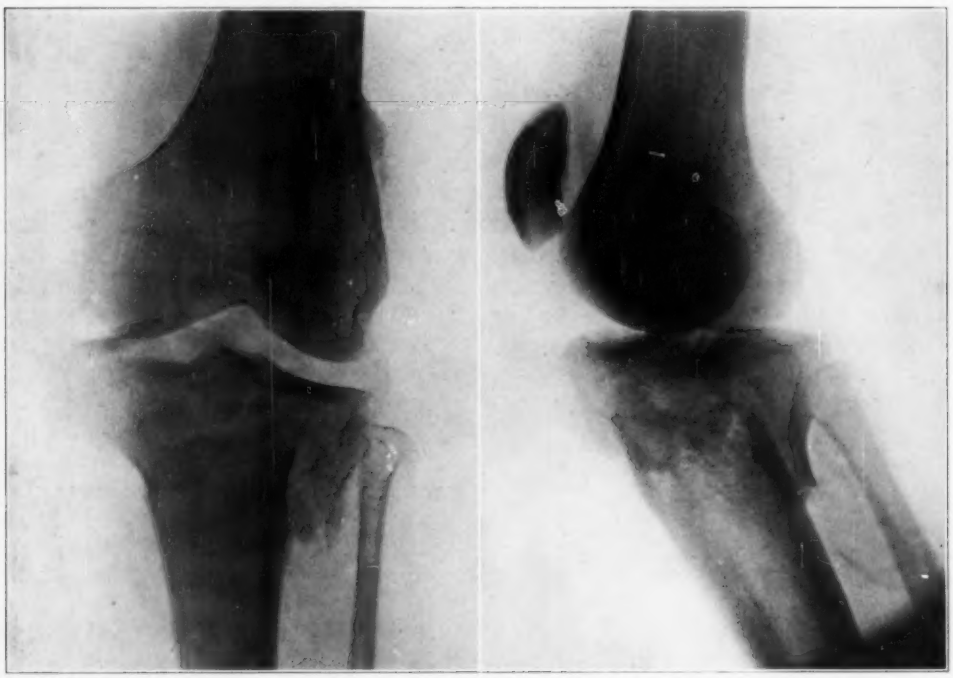

FIG. 3-A

Case 2. Showing lesion immediately after injury.

FIG. 3-B

Eight weeks after operation.

FIG. 3-C

Twenty weeks after operation.

spine. Of the two donor sites, the latter provides by far the more abundant supply of cancellous bone. It should be used when a generous amount of bone chips is needed (as in fusion of the knee or in filling a tibial defect), even if it means that the patient has to be turned during the operation and therefore has to be draped twice.

The cancellous bone of the ilium is exposed by cutting a window in the outer cortex, by turning up the crest as a lid, or by combining both procedures; the choice depends on the amount of bone chips needed. The cancellous bone can then be cut out easily with a hand gouge. This method obviates any danger of penetrating the inner cortex. This is of importance in the posterior approach, because of the proximity of the sacro-iliac joint, and Oldfield has reported hernia of the caecum following the removal of part of the whole

FIG. 4-A

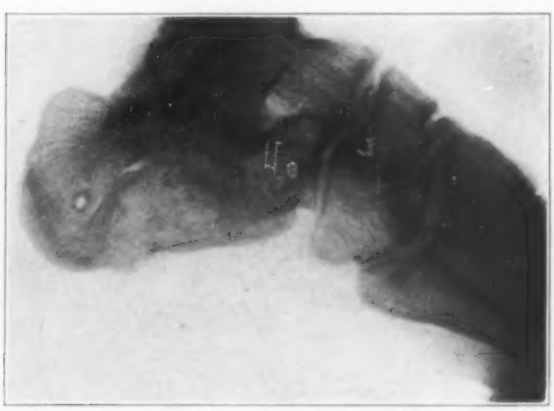

FIG. 4-B

Case 3. Subastragalar fusion.

Fig. 4-A: Twelve weeks after operation.

Fig. 4-B: Twenty weeks after operation.

thickness of the crest of the right ilium in front. The cancellous bone is cut into cubes, five centimeters on a side, or smaller.

FIG. 5-A

Case 4. Severe hallux rigidus before operation.

A hematoma forms more often in the anterior wound than in the posterior. In twenty-four posterior donor wounds there has been only one hematoma, and in eleven anterior wounds there have been three hematomata. More care is therefore needed with hemostasis in the anterior wound than in the posterior. The reason for the difference between the two sites in this respect is that a large muscle mass is cut in the posterior approach, and this, by its hemostatic effect, arrests the bleeding. The anterior crest is subcutaneous, and there is no natural local hemostatic. The importance of this point has only just been appreciated; with a little more care in hemostasis, hematoma formation in the anterior wound can be avoided.

The recipient area is prepared so that there is an immediate blood supply to the grafts. If a joint is to be arthrodesed, it is important not only to remove all the cartilage from the opposing joint surfaces, but also to open the cancellous bone at each bone end.

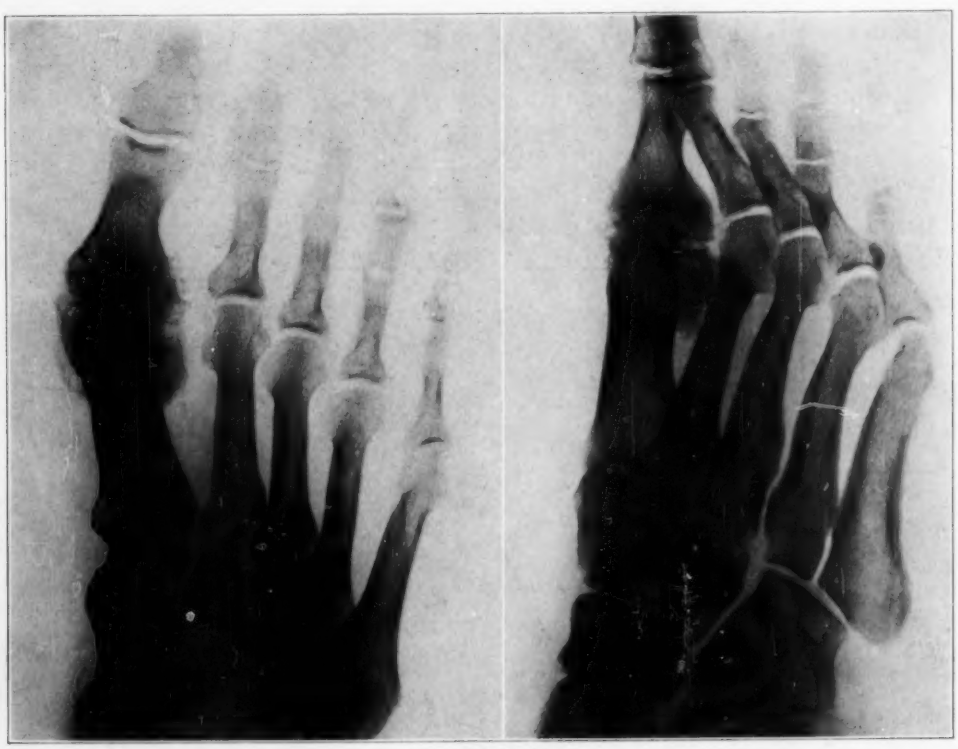

FIG. 5-B

Twelve weeks after operation.

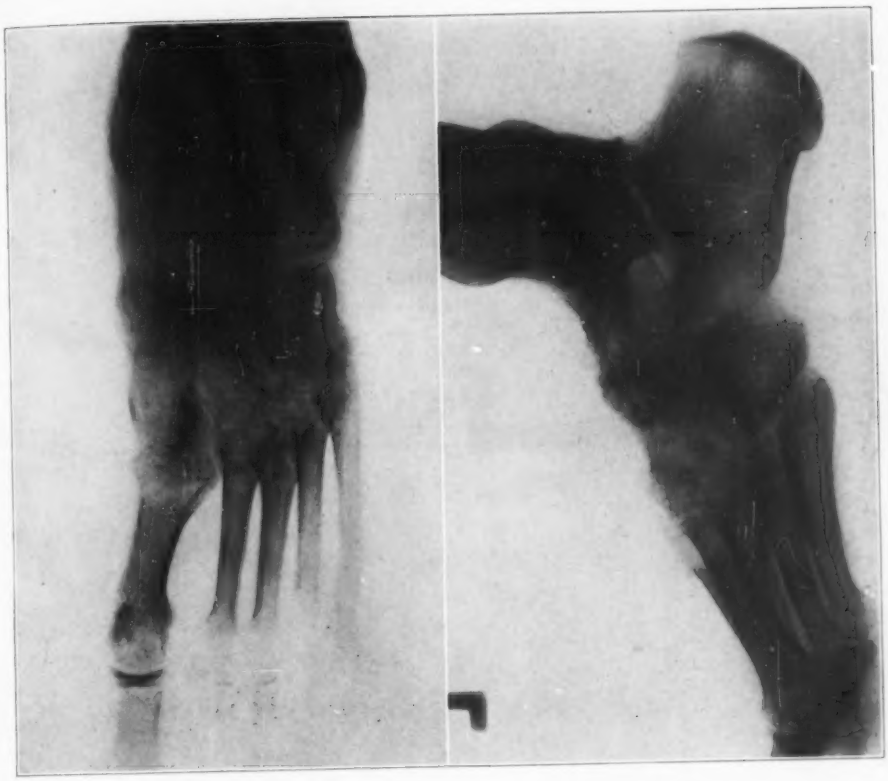

FIG. 6-B
Eight weeks after operation.

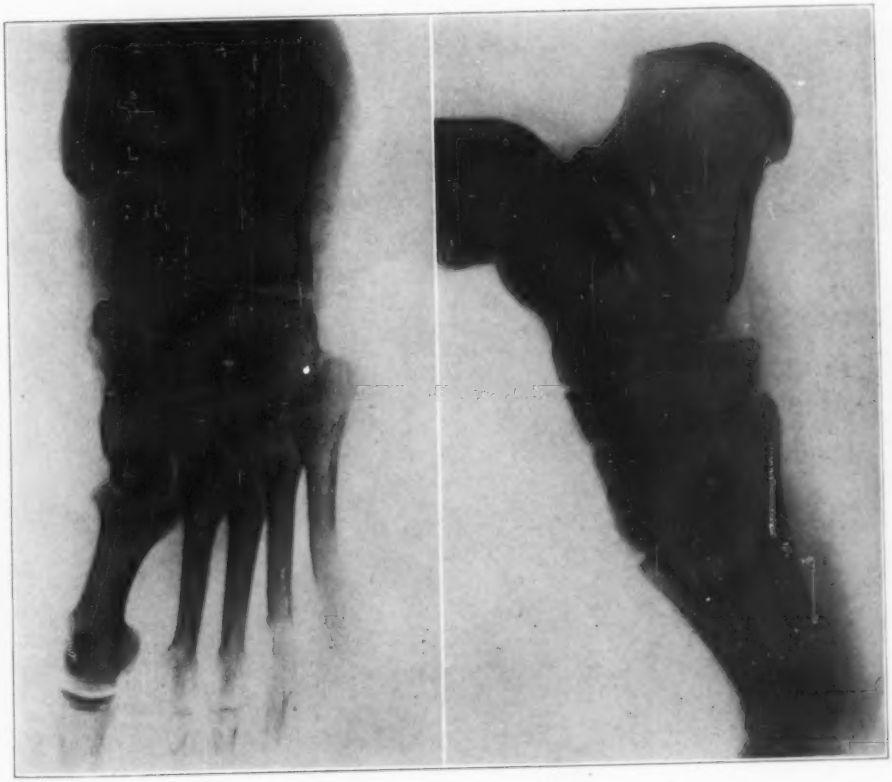

FIG. 6-A
Case 5. Immediately after injury.

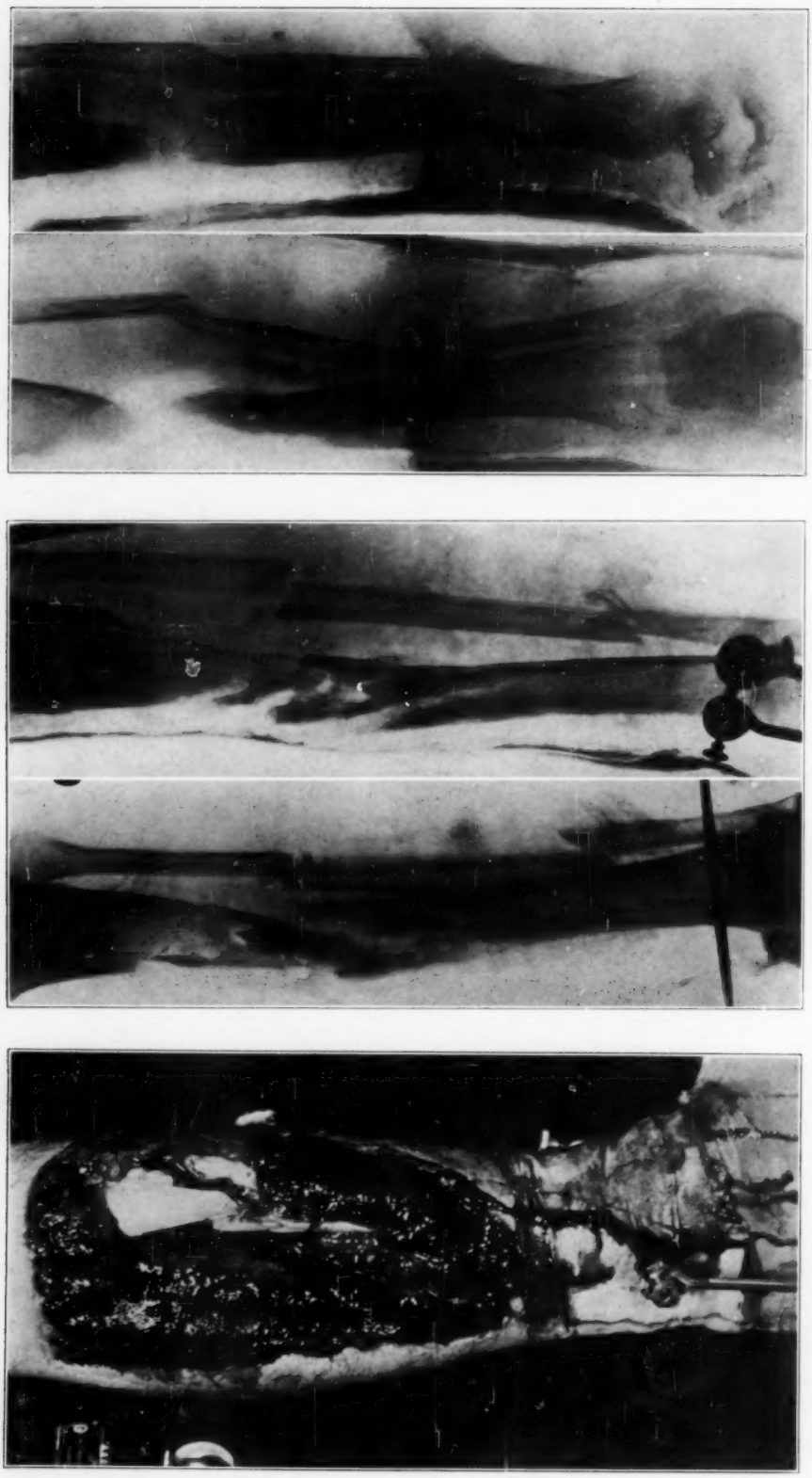

FIG. 7-C

FIG. 7-B

FIG. 7-A

Fig. 7-A: Case 6. Photograph immediately after injury.
Fig. 7-B: Roentgenogram soon after injury.
Fig. 7-C: Tibial defect after five months.

FIG. 7-D

FIG. 7-E

Fig. 7-D: Scar of poor quality covering tibial defect.
Fig. 7-E: Incision through cross-leg flap, fourteen days after bone-grafting.

If a bone defect is to be filled, the fibrous tissue between the bone ends, and the sclerotic bone ends themselves, must be cut away; healthy vascular bone above and below must be opened with saw cuts or by drilling; and the fibrous tissue covering the muscle bellies around the bone must be removed or incised. The cancellous bone chips are then packed into the cavity in the bone and around the shaft. Unless a rigid internal splint is used, the alignment of the limb is corrected by molding, during the application of the plaster. An advantage of iliac chips over rigid cortical grafts fixed by screws is that there is a second opportunity for manipulative correction of the alignment when the padded postoperative plaster is changed for a skin-tight plaster at the end of twelve to fourteen days. If any correction of alignment is needed, however, the change of plaster should not be delayed, for often by the fourteenth day, fusion is so advanced that the alignment can be altered only by the use of firm pressure, and it may be necessary to anaesthetize the patient.

CASE REPORTS

CASE 1. J. H., aged twenty-six, sustained a severely comminuted fracture of the body of the first lumbar vertebra when he jumped from an aircraft which had taken fire. The displacement was reduced by hyperextension in a plaster jacket, and a primary fusion of the twelfth thoracic vertebra to the second lumbar vertebra was made eight weeks later. The laminae of the vertebrae were rawed, the spines were rawed and split, and the whole area was packed with iliac chips. Figures 2-A and 2-B show the appearance after three months. Fusion was clinically solid, and there was no pain.

CASE 2. W. W., aged thirty-five, sustained a severely comminuted fracture of the tibial plateau in an aircraft crash (Fig. 3-A). It was decided that arthrodesis of the knee offered the only prospect of a

FIG. 7-H

FIG. 7-G

FIG. 7-F

Fig. 7-F: Postoperative roentgenogram, showing tibial reconstruction.
Fig. 7-G: Tibial reconstruction at twelve weeks.
Fig. 7-H: Tibial reconstruction at thirty-six weeks.

painless stable limb. After a small associated wound had healed, the joint was excised and packed with iliac-bone chips. When the postoperative plaster was changed at twenty-one days, the joint was already firm. Figure 3-B shows the appearance of the joint, eight weeks after operation. The patient began to walk in a guarding plaster at ten weeks. Figure 3-C shows the appearance at twenty weeks; all external fixation had been discarded, and the fusion was solid and painless.

Case 3. In R. S., aged twenty-three, the subastragalar joint was fused for painful osteo-arthritis, following a fracture of the os calcis. Iliac-bone chips were packed into a cavity cut in the back of the joint, through the posterior approach described by Gallie.[7] Fusion was clinically solid at twelve weeks (Fig. 4-A); Figure 4-B shows the appearance at twenty weeks. At that time the patient was free from symptoms.

Case 4. In G. H., aged forty, the first metatarsophalangeal joint was fused for crippling hallux rigidus (Fig. 5-A). Iliac chips were packed between the denuded ends of the bones. At twelve weeks, the fusion was clinically solid and not tender, and the patient was walking comfortably in ordinary footwear (Fig. 5-B).

Case 5. H. R., aged twenty-three, an air gunner, sustained a fracture of the tarsal navicular in a cycle accident. When the immediate effects of the injury had subsided, the affected joints were excised and the area was packed with iliac-bone chips. At eight weeks the fusion was clinically solid and not tender (Fig. 6-B).

Case 6. W. L., a twenty-one-year-old pilot, sustained severe compound and grossly comminuted fractures of the tibia and fibula (Fig. 7-A). The wound was badly infected, and for some time there was considerable doubt about the wisdom of trying to save the limb. Ultimately, a large portion of the shaft of the tibia sequestrated and was removed, and the remaining wound was healed with split-skin grafts and pinch grafts. A large tibial defect was left, covered by a wide adherent unstable scar (Fig. 7-D). This scar was replaced by a cross-leg flap and later, through that flap (Fig. 7-E), the tibia was re-

Fig. 7-H: Tibial reconstruction at thirty-six weeks.

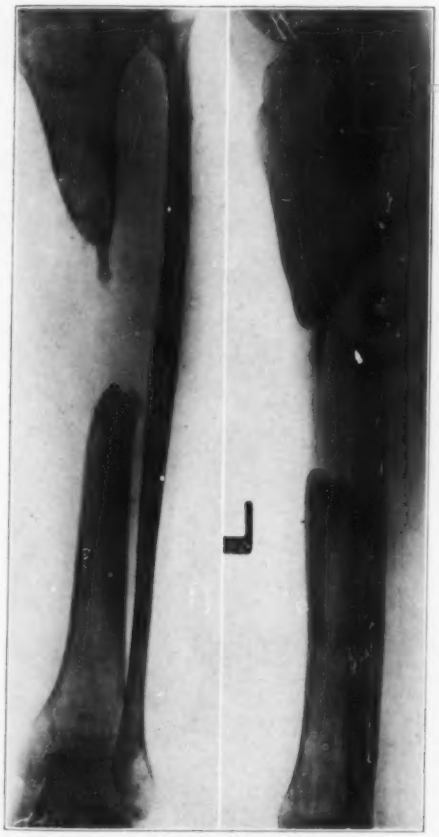

Fig. 8-A

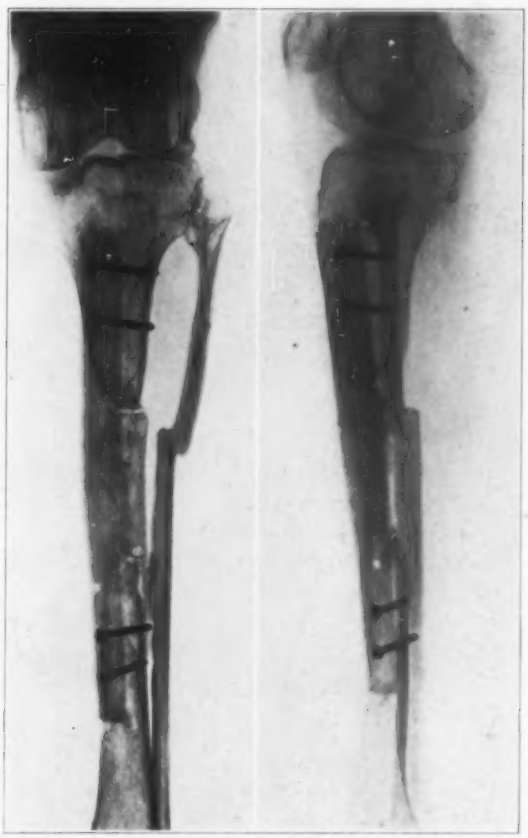

Fig. 8-B

Fig. 8-A: Case 7. Tibial defect, some months after associated wound had healed.
Fig. 8-B: Eight months after tibial reconstruction with cortical bone.

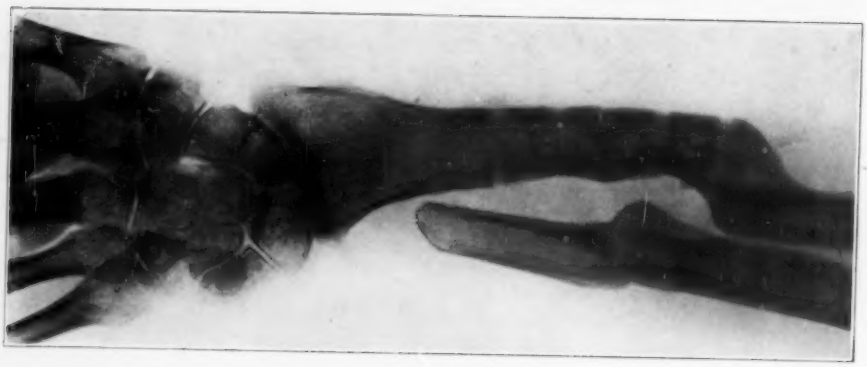

Fig. 9-D

Fig. 9-C

Fig. 9-B

Fig. 9-A

Fig. 9-A: Case 8. Rotation osteotomy of radius, unhealed at twenty weeks.
Fig. 9-B: Eight weeks after use of iliac chip grafts.
Fig. 9-C: Sixteen weeks after insertion of iliac chip grafts.
Fig. 9-D: Removal of plate at twenty-four weeks.

built with twin cortical onlay grafts from the other tibia; cancellous bone from the ilium was packed into the defect (Fig. 7-F). At the end of twelve weeks the patient was exercising the limb in bed (Fig. 7-G), and three weeks later he began walking with crutches. A stress fracture developed in the donor tibia six weeks after the operation, and as a result the rebuilt tibia took unsupported body weight four weeks before the donor tibia. Figure 7-H shows the rebuilt tibia at the end of thirty-six weeks.

CASE 7. F. C., aged twenty-four, had a tibial defect (Fig. 8-A), which was very similar to that of W. L. (Case 6). The tibia was rebuilt (by another surgeon) with a massive onlay graft of cortical bone, and a piece of cortical bone to bridge the gap. Although the rebuilt tibia ultimately consolidated satisfactorily, it was still in plaster at the end of eight months (Fig. 8-B); at this stage, consolidation was poorer than in W. L. at twelve weeks (compare Figures 8-B and 7-G).

CASE 8. W. K., aged thirty-one, sustained a very severe fracture of both bones of the forearm, which united with overlap and poor alignment. The head of the ulna was excised in an attempt to restore rotation. When first seen by the writer, about six months after this operation, the fractures were soundly united and the patient had reasonable forearm movement, including nearly 90 degrees of rotation. The range, however, was from full supination to the mid-position, and the movement was consequently of less functional use than had the range been between the mid-position and full pronation. A rotation osteotomy of the radius was accordingly performed, pronating the lower fragment, and the bone was fixed with a vitallium plate. Twenty weeks later the osteotomy was quite unhealed (Fig. 9-A). The bone ends were then excised between the two central screws, the shafts were drilled thoroughly above and below, and the cavity cut in the bone was packed with iliac chips. Figure 9-B shows the appearance eight weeks later; at the end of sixteen weeks (Fig. 9-C), there was no doubt that the bone was uniting; and when the plate was removed, at the end of twenty-four weeks, there was solid union (Fig. 9-D).

Fig. 9-C: Sixteen weeks after insertion of iliac chip grafts.
Fig. 9-D: Removal of plate at twenty-four weeks.

Cancellous chip grafts are of value in the arthrodesis of joints, in the repair of bone defects, and in some forms of non-union or delayed union of fractures. A cortical graft may be needed to preserve the shape of a bone, but if stability of the fractured bone can be maintained by means other than the use of a cortical graft, cancellous chips alone will produce union. The main disadvantage of a tibial bone graft is that it usually has to be cut from an intact tibia. Plates and screws of absorbable plastic material, used with cancellous chips from the ilium, would appear to be the ideal method of osteosynthesis.

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THE USE OF CANCELLOUS CHIPS IN BONE-GRAFTING *

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The principles and methods of bone-grafting have been well established for many years. In World War I and since, the results have been good, but the chief criticism has been that reconstitution of the bones has been slow.

It was, therefore, of the greatest interest to see a jaw which had been reconstructed in an incredibly short time by the use of chips from the crest of the ilium. The use of chips is, of course, not new, but the familiar tibial chips had but little osteogenetic power and could be seen as discrete fragments in radiographs taken long after the operation. The cancellous bone scooped out from the tibia was scanty and of poorer quality than cancellous bone from the ilium.

In order to explore the usefulness of these chips in orthopaedic surgery, seventy-one consecutive cases of bone-grafting have been reviewed, sixty of which were operations for non-union of the long bones. Of this latter group, cortical grafts alone were used in twenty cases, and cortical grafts plus cancellous chips were employed in forty.

All the operations have resulted in bony union, although in four cases the first attempt was not successful. One humerus, much of which had been destroyed in an air raid, was grafted three times, and another twice. In two cases of fracture, the tibae were grafted twice. In all four cases, the bones have now united. This refutes the opinion of those who believe that only a minority of bone-grafting operations are successful.

Complications were present in two cases, and in each the cause was the same. The operations were carried out through heavily scarred skin (one patient had had skin-grafting) and, owing to undercutting and tension, the skin sloughed at one point and the wounds did not heal, because of chronic infection. In both cases there is bony union, but further measures will be necessary.

Table I compares the healing time of grafts with cortical bone only and those with cortical bone plus chips.

TABLE I

Bones	Average Time of Union	
	Cortical Grafts Only	Cortical Grafts Plus Cancellous Chips
Humerus	16 weeks	8 weeks
Radius and ulna	17½ weeks	8 weeks
Tibia and fibula	17 weeks	8 weeks
Femur	22 weeks	14½ weeks

These periods of time cannot, of course, be stated accurately, but were based on clinical and radiographic evidence.

Of the eleven other bone grafts in the series, cancellous chips were used for filling bone defects or spaces. Five cases included an osteoclastoma, solitary cysts of the humerus and femur, and a case of osteitis fibrosa cystica. In six cases, chips were employed to hasten ankylosis in arthrodesing operations on the sacro-iliac, knee, ankle, and hip joints.

The method of taking chips from the iliac crest is illustrated in another paper.[1] It is of great advantage if an assistant can take the chips while the cortical graft is being removed from the tibia, as this saves time. The taking of chips adds to the length and sever-

* Read at the meeting of The British Orthopaedic Association, London, June 1, 1945.

FIG. 1-A
Before operation.

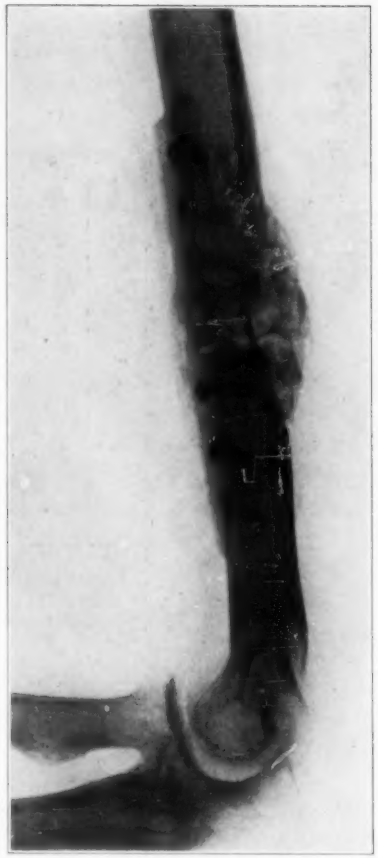

FIG. 1-B
After operation.

Fig. 1-B shows onlay cortical graft with cancellous chips, approximately six weeks after operation. Bone chips have fused, forming mass of new bone.

FIG. 2-A
Before operation.

FIG. 2-B
After operation.

Loss of bone was due to gunshot wound. Defect was bridged by cortical onlay graft and chips. Radiograph approximately three weeks after operation shows individual chips still visible.

weeks after operation shows individual chips still visible.

FIG. 3-A
Before operation.

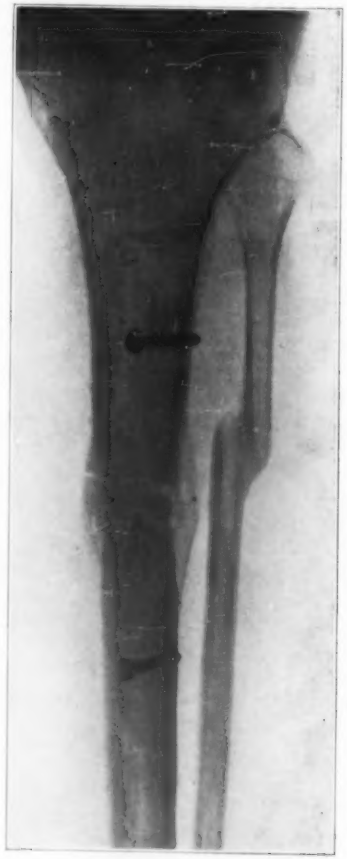

FIG. 3-B
After operation.

Inlay graft was held in position by two vitallium screws. The more rapid growth of the cancellous chips in contact with muscle illustrates the importance of an adequate blood supply for the growth of cancellous bone.

FIG. 4-A
Before operation.

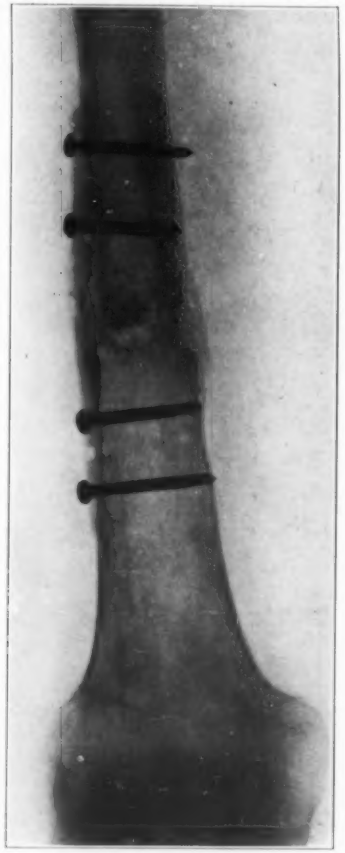

FIG. 4-B
After operation.

Fig. 4-B shows onlay graft with cancellous bone packed in and around fracture line after excision of sclerotic bone.

ity of the operation, but should not give rise to any serious anxiety. The iliac wound is a source of discomfort for only a few days. A drip transfusion of saline is given during the operation, followed, if necessary, by a blood transfusion.

For the use of cancellous chips to be successful, rigid fixation is necessary. To work through a window in a plaster, as has been done, adds to the difficulty and, even then, fixation is not likely to be very secure. To maintain length and alignment and provide immobilization, cortical grafts seem entirely satisfactory. The value of plates is less definite. The type of cortical graft depends upon the bone, and the following types have been employed: for the humerus, a screwed-on onlay; for the radius and ulna, an onlay or inlay; for the tibia, a sliding inlay or an inlay from the other leg; and for the femur, an onlay.

When chips are used to fill the gap, there need be no hesitation in removing all sclerosed bone. The chips are packed between the bone ends and around the fracture line, and often are kept in place by a guarding sliver.

To ensure a blood supply, all scarred and fibrous tissue must be removed; and, where possible, bare muscle should be brought into contact.

It is essential that the skin should be sound and not adherent. Bone is being added and it must be possible to bring the skin together over the increased bulk without tension. The help of the plastic surgeon in providing full-thickness skin has been invaluable.

Many of the cases reviewed had recently been septic, due to old gunshot wounds and bomb injuries. The rule of World War I, that a year must elapse after the end of all sepsis before bone-grafting should be undertaken, no longer holds. With penicillin and sulfanilamide powder, there should be very little trouble and no disasters.

In conclusion, the use of cancellous chips taken from the crest of the ilium has been found of decided value in bone-grafting. The chief advantages of this procedure are as follows:

1. In even "straightforward" cases, the chips will shorten, by approximately one half, the time required to produce firm union.

2. The chips, in conjunction with cortical grafts, are of great aid in filling gaps in long bones.

3. The chips are useful for filling bone defects, as, for example, after curetting cysts, and in packing the crevices and gaps in arthrodesing operations.

4. In the treatment of chronic osteomyelitis, the use of chips also plays a part.

1. Robertson, I. M., and Barron, J. N.: A Method of Treatment of Chronic Infective Osteitis. J. Bone and Joint Surg., **28**: 19–28, Jan. 1946.

A METHOD OF TREATMENT OF CHRONIC INFECTIVE OSTEITIS *

BY IVOR M. ROBERTSON, F.R.C.S.E., AND JOHN N. BARRON, F.R.C.S.E.
ST. ALBANS, ENGLAND

During the past few years, due to the introduction of penicillin and to the stimulus of war, there has been a gradual realization of the necessity for a revision of the treatment of such conditions as chronic osteitis. The pathological changes that occur in chronic osteitis are too familiar to require repetition, but it should be stressed that the bone and soft-tissue reactions to injury are intimately related, and must be considered together (Fig. 1).

In chronic osteomyelitis, the presence of sinuses and of superficial and deep fibrosis leads to a series of changes in the overlying skin and surrounding tissues, which result in permanent impairment of the vascular and lymphatic supply of the area. In chronic osteitis resulting from infected compound fractures and gunshot wounds, the effect on the surrounding tissues is incomparably greater; and the destruction of tissue by necrosis and suppuration leaves a dense, infected scar. It is thus rational that, in formulating any method of dealing with chronic osteitis, the treatment of infected and damaged soft tissue be considered of equal importance.

FIG. 1

The anterior internal aspect of the middle third of the left leg, showing multiple sinuses with skin adherent to underlying bone.

The principles and technique elaborated by Orr, and later applied in slightly modified form by Trueta for the management of war wounds, have now become the generally accepted methods of treatment for chronic osteitis. Under this regimen, the wounds are saucerized and then packed; healing by granulation tissue and scar epithelium is encouraged, drainage and splintage being maintained by the closed-plaster technique.

SUGGESTED TREATMENT OF CHRONIC OSTEITIS

The treatment is based on the principle of extensive excision of all diseased tissue, including skin, deep scar, and infected bone; and the replacement of soft-tissue defects by muscle and skin flaps, and of bone defects by bone transplants. The aim is to remove the whole of the local disease and to establish normal conditions in the tissues. This requires either two or three operative stages, as follows:

Stage 1: The excision of all diseased tissue and the application of a split-skin graft to the wound surface (Figs. 2 and 3).

Stage 2: The plastic repair of the soft tissues. The split-skin graft is removed and the area is covered by a skin and subcutaneous-tissue flap, muscle being included where necessary.

Stage 3: The repair of the bone defect (Fig. 4).

In some cases, Stages 2 and 3 can be combined. An interval of four weeks should be left between the first and second stages, and at least six or eight weeks between the sec-

* Read at the meeting of The British Orthopaedic Association, London, June 1, 1945.

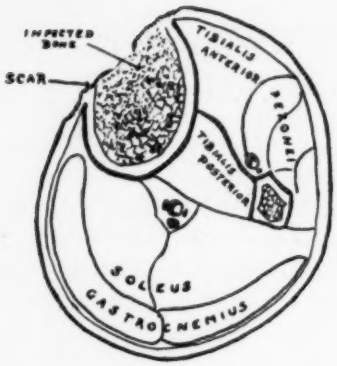

FIG. 2

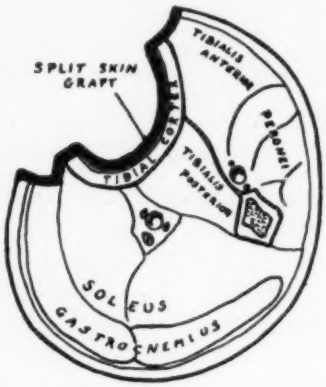

FIG. 3

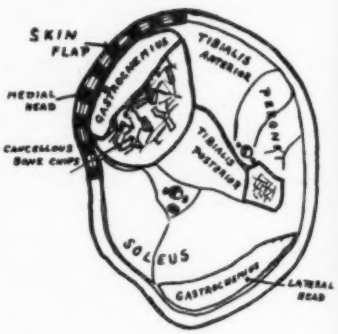

FIG. 4

Fig. 2: Diagram of area of chronic osteitis with overlying adherent, scarred, and ulcerated epithelium.

Fig. 3: Diagram of first stage of operative treatment. All scarred and infected soft tissue and bone are excised, and the area is covered with a split-skin graft.

Fig. 4: Diagram of second and third operative stages. Bone defect is filled with cancellous chips; soft-tissue defect is covered with muscle and full-thickness skin flap.

ond and third stages. Penicillin is used for twenty-four hours before operation at each stage, and is continued for four days after operation; 100,000 units each twenty-four hours are given by intramuscular drip.

This cannot be considered as a method of treatment for chronic osteitis in general. In the cases selected, the infected area should be accessible to surgical approach, and the site and extent of the disease should be such that a complete excision of this area is possible.

While the lesions of chronic bone infection are essentially the same in the upper and lower limbs, the surgical difficulties associated with the repair of wounds affecting the lower extremities are considerably greater. The majority of the patients already treated by this method have been cases of chronic osteitis of the leg,—the result of hematogenous infection, infected compound fractures, or gunshot wounds.

Stage 1: Extensive Excision of all Infected Bone and Scar Tissue, and Split-Skin Dressing

For the first part of this operation an Esmarch bandage should be used.

Skin: Excision of sinuses with adherent, infected, and scarred areas of skin must be complete. The skin flaps are not undercut more than is necessary to give adequate exposure of the whole infected area, thereby not only limiting the risk of exposing uninfected regions to contamination, but also minimizing the chance of endangering the blood supply of the skin. An atraumatic technique is of particular importance, because of the already diminished blood supply.

Soft Tissues: It is of the utmost importance that, while preserving intact all vital structures such as nerves and blood vessels, the dissection of scar tissue be as complete as possible and extend into healthy vascular tissue. Thus further infection can be reduced to a minimum, and an adequate blood supply can be obtained for future surgical procedures.

Periosteum: Similarly, normal unscarred periosteum should be left intact as far as possible, and should be handled with the greatest care. Periosteal stripping should be limited to that required for access to the diseased areas.

Bone: Systematic removal of diseased bone is essential. It is usual to commence at one end, and to cut away, layer by layer, the whole of the affected area until a smooth open surface of normal vascular bone remains (Fig. 6). This entails the complete effacement of all cavities, even if normal bone has to be sacrificed, and includes the removal of all sequestra and necrotic tissue. The exception to this rule will be found in defects in-

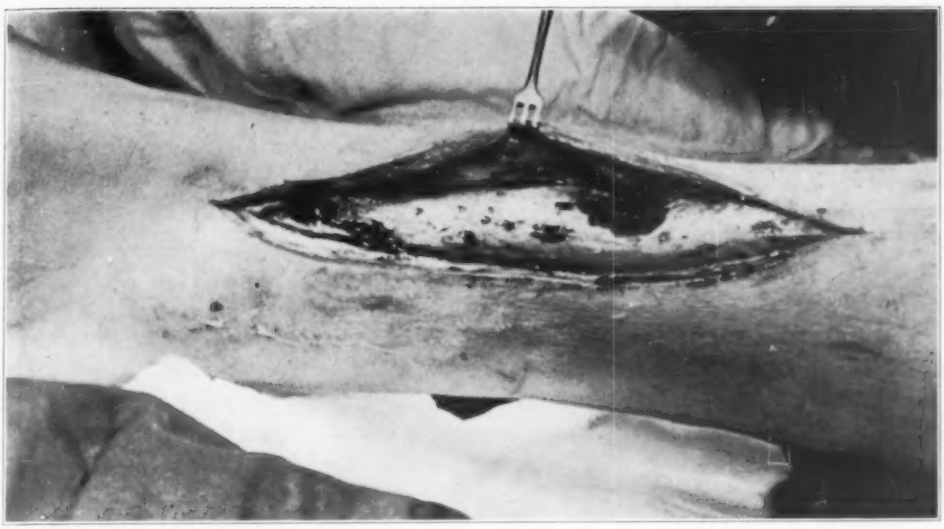

FIG. 5

Scarred and infected soft tissue has been excised, exposing full extent of infected bone.

volving the extremities of the long bones, where saucerization may be impossible, owing to proximity of the joint surface.

In compound fractures, it is frequently found that the infective process has involved the full diameter of the shaft, and indeed may have extended to the soft tissues beyond. These fractures usually fail to unite, and the wound becomes a chronic abscess cavity, two sides of which consist of bone faced by infected fibrous tissue. Bone removal should proceed to an oblique resection of the ends, cutting back until normal structure is revealed. This will provide access to the scarred periosteum and to the muscle which forms the deep wall of the infected area.

In cases where a bridge of osseous union is found, in spite of continued infection, a decision must be made as to whether the bony bridge is sufficiently vascular to be allowed to remain. This decision is of great importance and, with the bone-grafting methods to be described, there should be no hesitation in sacrificing bony continuity when that procedure seems wise.

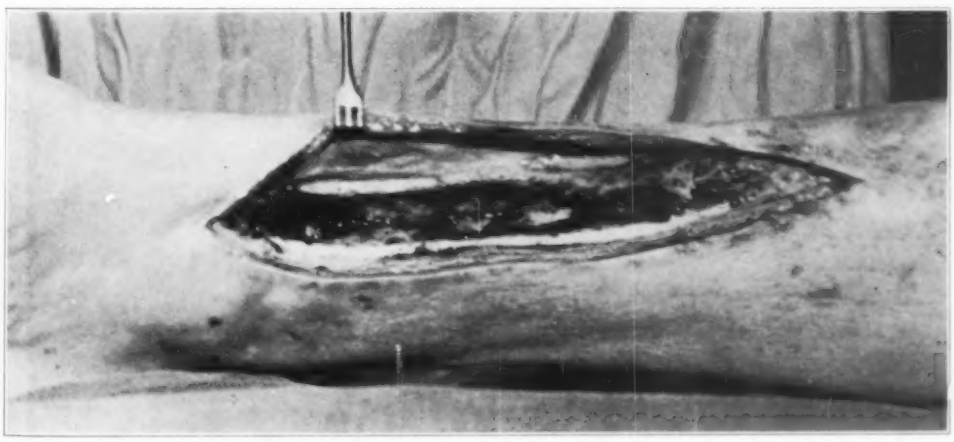

FIG. 6

Area of bone excised during first operative stage.

Split-Skin Grafting

Contrary to widespread belief, split-skin grafts can be expected to survive in the presence of infection of the recipient area. The survival and growth of the transplanted tissue depends upon the surgical technique employed, and upon the use of chemotherapy. Furthermore, as the illustrations in this paper demonstrate, there is no doubt that cortical bone is a suitable temporary host for the grafted epithelium. The skin dressing protects the bone and surrounding soft tissues from the effects of infection and scar replacement. Thus it ensures the integrity of the remaining muscular tissue and the vascular supply, and so increases its resistance to infection. As a result, the reconstructive procedures can be completed at an early date without undue risk of reinfection.

1. Preparation of the graft bed: The tourniquet is removed, all large vessels are carefully picked up, with a minimum of surrounding tissue, and are tied with 6-0 plain catgut. Small oozing points are grasped with fine hemostats, which are allowed to remain on for a few minutes. The wound is then packed with a hot swab and the limb is elevated until the general surface weeping ceases. A little patience is necessary, as five minutes may elapse before the bed becomes really dry. This period may be spent in cutting the skin graft, if the opposite thigh is to be used for this purpose.

When the leg is again lowered to the table, the only surfaces which may continue to give trouble are the cut bone ends. An effective procedure is to cover them with small swabs saturated with thrombin (in a strength of 500 units per cubic centimeter) and to apply pressure for a further period. When the swabs and hemostats have been removed, the whole wound surface should be ready to receive the skin.

2. Application of the skin: A thin split-skin graft of sufficient size to cover the wound is cut and spread out on tulle gras or vaseline gauze. It is punctured in several places with a knife, so that drainage from the wound surface can be absorbed into the dressing. The

FIG. 7-A

FIG. 7-B

Fig. 7-A: Roentgenogram of gunshot wound of upper third of tibia, showing large cavity which was partially filled with infected scar tissue and granulations, with surrounding necrotic and infected bone.

Fig. 7-B: After excision of all infected tissue.

FIG. 9-B

FIG. 9-A

Fig. 9-A: Roentgenogram of gunshot wound of tibia with probe leading down sinus to necrotic bone with central sequestrum.
Fig. 9-B: Note extent of bone excised.

FIG. 8-B

FIG. 8-A

Fig. 8-A: Roentgenogram of compound fracture of tibia which had been plated, and subsequently became infected. Note large area of necrotic bone with central sequestrum.
Fig. 8-B: After first stage in treatment. Note extent of bone excision required, and new-bone formation in fibula.

wound is then lightly dusted with penicillin powder, the graft is laid on, and pressed down into the contours. The skin and tulle gras are stitched to the wound edges, the ends of the sutures being left long enough so that they may be tied over the dressing as an aid to immobilization. Wool wrung out in normal saline is packed down over the graft, so that an accurate mold is made which will distribute pressure equally over the whole area when a bandage is applied. The long sutures are tied over the wool mold, the limb is encased in wool, and bandaged with an elastic bandage, firm, even pressure being used. A light plaster cast is applied over all.

Postoperative Care

After the operation the limb is elevated, but receives no attention for two weeks. It is then dressed for the first time, when it may be either healed or there may be patchy failure of the graft. In our experience an 80 per cent. "take" of the skin was the poorest result, and the average was about 90 per cent. Loose skin tags and desquamating surface epithelium are cut away and the graft is thoroughly washed. It is then painted with 10 per cent. mercurochrome and a further dressing is applied, similar to that used at operation, except that no sutures now remain. A plaster back splint is retained, and no further interference is required for a week. Then the massive dressings are discarded, exercise therapy is instituted, and the wound is dressed every second day. Any remaining granulations are painted with mercurochrome and covered with a light gauze pack; epithelialization is usually complete within ten days.

FIG. 10

Stage of excision completed. Split-skin graft lining cavity and covering bone. Skin graft "take" complete in four weeks.

FIG. 11

Second stage completed (see Figs. 8-A and 8-B). Cross-leg flap covering bone defect.

Stage 2: Repair of Soft Tissues

At this stage we are faced with a composite defect in the limb, consisting of loss of bone, muscle, subcutaneous tissue, and skin. The ideal to be aimed at is replacement by similar tissues. The main problem is the provision of a stable scar-free skin cover. The split-skin graft has done its work as a temporary dressing, but being for the most part based on bone, it is too vulnerable. It must, therefore, be replaced by a viable flap of skin and subcutaneous tissue; but it should be remembered that it is difficult to design a flap to fit a concavity. A dead space is disastrous.

Where the depth of the bony cavity is such that no skin flap can be designed to fit it, use is made of muscle flaps and cancellous iliac bone to fill the defect, over which complete skin closure can be obtained.

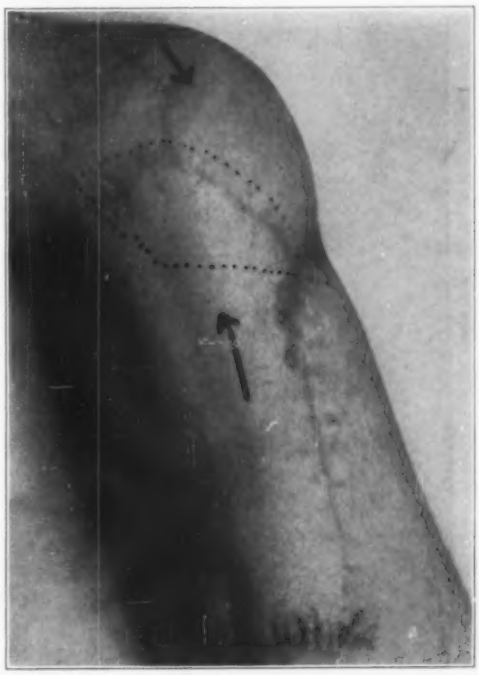

FIG. 12

Second and third stages combined. Double-rotation flaps used in repair of skin defect, which is indicated by dotted line.

Types of Skin Replacement

1. Local plastic operations

The *rotated* flap is ideally suited to fill a triangular defect. It is designed on generous lines and is based proximally. Allowance must be made for the fact that it is not being used on a flat surface, but around the circumference of a limb (Fig. 11). Any secondary defect that is left after the flap has rotated should be arranged to lie over the posterior calf muscles, where a split-skin graft will be satisfactory. Tension should not be relied upon to effect closure.

The *transposed* flap is cut of the pattern of the wound and transposed on a pedicle from a suitable aspect of the limb, leaving the secondary defect in a position where it can be grafted.

The *bridge* flap has a double base and is raised as a strap. Its movement is limited and depends mainly upon stretch and the elasticity of the skin. It is best suited to fill elliptical defects, where maximum closure is required in the center of the wound.

Local plastics on the leg are fraught with difficulty and there are certain limiting factors. The blood supply of the skin, notoriously poor at best, is often very much depleted in an atrophic limb which has been lying for months encased in plaster. Cutting a flap still further embarrasses the circulation to the area, and every allowance must be made for this.

The transverse width of the wound indicates whether a local plastic should or should not be used. A defect measuring more than two inches across should be carefully considered before the decision is made to repair it locally, but usually it is better to import skin from elsewhere.

The surgical procedure of "delaying" a flap gives a margin of safety in doubtful cases. The flap is outlined and undercut, then sewed back into position. This encourages an augmented blood supply through the base, and ten to fourteen days later the flap can be rotated or transposed with safety.

2. Repair from a distance

The *cross-leg* flap is the most satisfactory method of importing skin. The legs are apposed in such a position that the defect to be covered is approximated to the upper half

FIG. 13-A

Roentgenogram of gunshot wound of the external condyle of femur. Area of osteitis shown with surrounding sclerosis.

FIG. 13-B

Bone cavity, caused by excision of infected bone, is successfully filled with cancellous chips and covered by full-thickness skin.

of the opposite calf. A flap is designed on the calf to bridge the gap between the legs and to fit the defect. This flap is either "delayed" or, if the circulation is satisfactory, is sewed into the recipient leg, and its donor site is covered with a split-skin graft. Plaster immobilization retains the legs in position for two or three weeks, at which time the skin bridge is cut and the repair is completed.

The *abdominal tubed pedicle*: This multistage method may be used when the defect is too extensive to be repaired by other means. The pedicle is created and transferred to the leg by way of an intermediate attachment to the wrist. The main difficulty arises in the arm-to-leg position, where maintenance of an awkward posture may be necessary. Good nursing is essential.

FIG. 14

Bone defect repaired by autogenous onlay graft and cancellous bone chips.

Defect Filling by Muscle Flaps

In the deep cavities which result from infected-bone clearance in the upper tibial and lower femoral regions, it is often advisable to transpose muscle as well as skin. This minimizes the amount of cancellous bone required and provides an excellent source of blood supply.

The most suitable case is a deep medial, upper tibial defect. Here the medial head of the gastrocnemius is removed from the Achilles tendon and dissected up, leaving the branches of the medial sural artery and the nerve supply intact. When freed, this muscle is rotated over to fill the defect left after sufficient iliac bone has been packed in to ensure strength, and is sutured to the periosteum on the lateral edge of the defect. The skin cover is then sewed in over the muscle.

Similar muscle flaps can be used elsewhere, but strict attention should be paid to the conservation of the blood and nerve supply. A vascular muscle transplant is highly resistant to infection and provides a capillary bed from which the grafted bone is revascularized.

It is advisable to allow a period of at least six to eight weeks to elapse, following any extensive plastic repair of the skin and soft tissues. This permits the new blood supply to the area to become firmly established and also allows time for the reaction, consequent on any operative procedure, to subside. During this latent period every endeavor should be made to assist the recovery of the normal physiological processes in the limb as a whole.

Splinting

Splinting should be reduced to the minimum. A light plaster back splint to limit mobility at the fracture site and to prevent foot drop is all that is usually required. This can be used at night and removed during part of the day for physiotherapy.

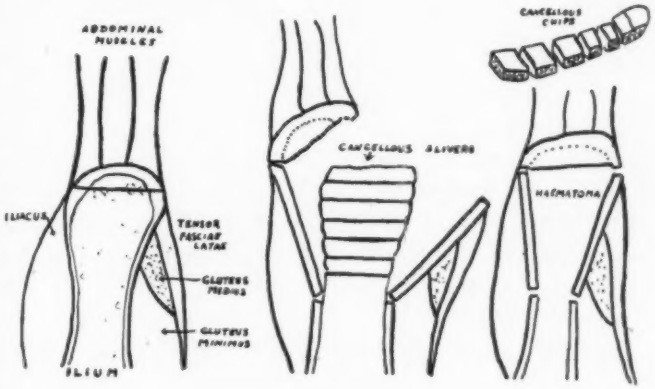

FIG. 15

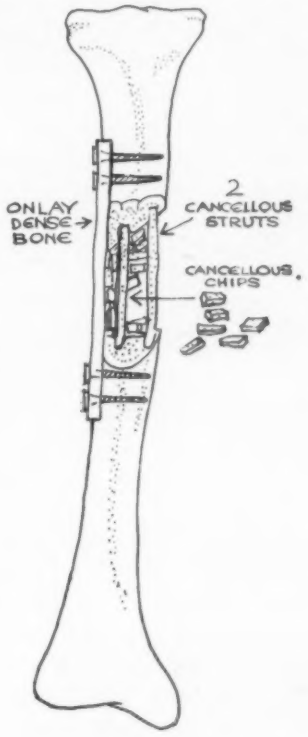

FIG. 16

Fig. 15: Diagram of operative procedure for obtaining cancellous bone from crest of ilium.
Fig. 16: Illustrating onlay graft in position and method of inserting cancellous bone. Note wide medullary exposure, into which cancellous struts are slotted and remaining defect built up with chips.

Physiotherapy

This should include mobilization of all joints, particularly those of the foot, ankle, and knee. Active exercises for the muscles of the limb, assisted if necessary by faradism, will do much to improve their tone and will improve general vascular and lymphatic supply. This preliminary treatment prior to bone-grafting is of great importance, since success in the filling of bone defects by cancellous bone chips depends largely on an adequate blood supply.

Stage 3: Bone-Grafting

Filling of Defects

As already stated, the repair of the bone defect can in certain cases be carried out at the same time as the reconstruction of the soft tissues. The bone surface is broken up with an osteotome, so that better contact can be made with the cancellous chips; and these are packed in until the cavity is filled. If a muscle flap is to be used, it should be sutured into place and the skin closure completed.

Bridging of Defects

In chronic infected compound fractures and gunshot wounds, where a substantial gap exists between the bone ends, bone-grafting has been attempted only after the two previous stages have been successfully accomplished. The method employed has been similar to that used as routine for bone-grafting fractures with non-union, the results of which have already been described by Higgs.[1] A strong autogenous cortical graft is used chiefly as a splint to maintain internal fixation, and cancellous chips have been relied upon for the production of new bone. Although the inlay graft can be used, the onlay graft (Fig. 14) has been found to give better fixation and allows the cancellous chips to be placed in direct contact with the medullary cavities, thus obtaining the maximum blood supply. If cancellous chips are simply packed in between the two bone ends there is a tendency, even when the cancellous bone shows evidence of active growth, for a line of non-union to develop between the chips and the host. For this reason it is important that strips of cancellous bone should be slotted into the upper and lower fragments (Fig. 16) so that a true bridge is formed between these two fragments. Bone chips can then be packed in between these strips until the full thickness of the defect has been made good.

Method of Obtaining Cancellous Bone

An incision is made along the anterior margin of the crest of the ilium, commencing at the anterior superior iliac spine, and extending for five or six inches. The incision is deepened, the crest of the ilium with its muscular attachments is elevated as a "lid", and the inner and outer tables of compact bone are separated and gently retracted, exposing a mass of pure cancellous bone. Strips of bone, usually 0.67 of a millimeter thick, are shaved off with an osteotome and are cut into chips about one centimeter long. Bleeding can usually be checked with hot packs. The inner and outer tables are then replaced, the "lid" is sutured back into position, and the skin is closed. It is unnecessary to drain the wound, provided a firm pressure dressing is applied immediately by means of a spica bandage.

CONCLUSIONS

This complicated procedure requires the intimate cooperation of the orthopaedic surgeon and the plastic surgeon. It is an undertaking not lightly to be embarked upon, and special nursing and hospital facilities are essential for success.

It is hoped that further experience will result in simplification of the methods used, and so permit their wider application to the problems of bone sepsis.

1. Higgs, S. L.: The Use of Cancellous Chips in Bone-Grafting. J. Bone and Joint Surg., **28**: 15–18, Jan. 1946.

PYOGENIC OSTEOMYELITIS OF THE SPINE

Differential Diagnosis Through Clinical and Roentgenographic Observations

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Pyogenic osteomyelitis of the spine often presents differential diagnostic problems that are baffling. Such problems arise in cases in which the manifestations are relatively mild and some other type of spinal disease has to be considered, and those in which the presenting symptoms apparently refer not directly to the spine, but elsewhere,—as to the meninges, chest, abdomen, or hip. The intimate anatomical relation of the spinal and peripheral nerves to the infected vertebrae and the lower grades of virulence possible in many of the infecting pyogenic organisms give rise to these problems.

This study is based upon forty-eight cases of pyogenic osteomyelitis involving the vertebral body or neural arch, occurring in the cervical, thoracic, or lumbar regions, observed in the Department of Orthopaedic Surgery, State University of Iowa, from September 1934 to March 1945.*

The diagnostic problems presented by these forty-eight cases may be divided into two main groups: first, location of the lesion; and, second, determination of its nature. In the latter group, the correlation of the stage of development of the infections due to different organisms with the changes seen in the roentgenograms is of diagnostic interest.

CLINICAL SYNDROMES

I. The Hip-Joint Syndrome

Acute pain in the region of the hip joint, flexion contracture, and limitation of movement associated with pain, when accompanied by high temperature, toxaemia, and marked leukocytosis, usually lead to a tentative diagnosis of acute suppurative arthritis of the hip joint. When general and local symptoms are not so marked, the possibility of a tuberculous coxalgia arises.

In only two of our cases were the general and local symptoms of sufficient intensity to warrant consideration of the possibility of an acute suppurative arthritis of the hip joint.

When hip pain is due to a spinal condition, careful examination of the hip joint reveals three main findings that, as a rule, can be relied upon:

1. Palpation of the posterior aspect of the articulation produces no pain;
2. Trochanteric percussion usually produces pain in hip conditions, but not in spinal conditions;
3. Restriction of motion is usually confined to extension of the thigh.

Physical examination of the lumbar spine may then confirm the suspicion of a lumbar lesion by revealing the following findings:

1. Presence of a point or circumscribed area of tenderness to pressure over the affected vertebrae, associated with local muscle spasm;
2. Marked limitation of movement of the spine, particularly flexion;
3. Pain in the lumbar spine following any attempt at extension of the leg.

II. The Abdominal Syndromes

In cases in which the spinal lesion is a pyogenic osteomyelitis, high temperature, pain, sharp muscle spasm in the right lower abdominal quadrant, and slight cutaneous hyperaesthesia may be the presenting symptoms, and the laboratory studies may show marked leukocytosis and deviation of the Arneth index.

* For a general analysis of the sixty cases of this condition seen in the University of Iowa Hospitals up to September 1934, see report of Kulowski.

Carnett has called attention to intercostal neuralgia in patients complaining of abdominal symptoms, and has worked out several clinical tests which enable the examiner to differentiate between an abdominal pain due to abdominal disease and one due to an extra-abdominal lesion. These tests are based upon the fact that, if the condition is an abdominal one, local abdominal pain present during palpation diminishes or practically disappears when the patient contracts his abdominal muscles; whereas, in cases in which the cause of the local tenderness is pressure by the vertebral lesion on the roots of the nerves of the abdominal wall, no change appears.

Among our cases there was only one in which it was necessary to make a differential diagnosis between acute appendicitis and vertebral osteomyelitis.

A woman (N. R. K. — 10357), whose osteomyelitic lesion involved the eleventh and twelfth thoracic vertebrae, complained several times of pain in her back, radiating down both sides of the abdomen. As a rule, these pains were not severe, but one day all the symptoms of acute appendicitis developed. The appendix was removed and the symptoms disappeared. Two weeks later, while the patient was still in the Hospital, abdominal pain again developed, and there was resistance to pressure in the right lower quadrant, accompanied by slight elevation of temperature and leukocytosis; this lasted for two days. Temperature ranging between 100 and 102 degrees continued for two weeks, during which time the patient had two similar attacks. All symptoms disappeared after the patient was placed on a Bradford frame, with traction, for one month.

III. The Meningeal Syndrome

In some cases the osteomyelitic process is characterized by an acute onset of high temperature, malaise, vomiting, headache, and clinical signs of meningeal irritation. In other cases the onset is more insidious, without elevation of temperature, but with marked generalized spinal pain and positive Kernig and Brudzinski signs. From the symptoms, an acute suppurative meningitis or a tuberculous meningitis is suspected until an analysis of the spinal fluid and the roentgenograms show an osteomyelitic focus, accompanied by a meningeal reaction.

Three of our cases presented the meningeal syndrome.

One patient (O. V. R. — 38-15274), a boy of eleven years, showed all the symptoms of acute infectious meningitis. Several days before his admission to the Hospital another patient from the same town had been admitted to another service with similar symptoms. Epidemic meningitis and tuberculosis were ruled out on the basis of negative findings in the spinal fluid — including smears, cultures, and guinea-pig inoculation — the evolution of the process, negative tuberculin and agglutination tests, and the appearance, two weeks after onset, of a destructive process localized in the inferior epiphyseal region of the ninth thoracic vertebra, accompanied by a narrowing of the corresponding intervertebral disc. The clinical symptoms disappeared two weeks after onset. The patient has been followed for eight years; the only abnormality present is a diminution of the intervertebral space between the ninth and tenth thoracic vertebrae, with what appears to be a calcification of the nucleus pulposus.

The other two patients presented similar symptoms, except that in both cases the temperature rise and systemic reaction were minimal. One was ten and the other twenty years old. In both patients the tuberculin tests, smears, guinea-pig inoculation, and agglutination tests were negative. The roentgenograms became positive between three and four weeks after the onset of symptoms, and showed localized lesions at the level of the epiphyseal regions, with coincident narrowing of the intervertebral disc.

IV. The Back-Pain Syndrome

At the time of admission to the Hospital, forty-two of our patients complained of pain in the back. According to the onset and the intensity of clinical symptoms, they may be placed in one of the three classical groups: acute, subacute, and insidious. The peculiar differential diagnostic problems of each group may be stated as follows:

A. Acute Form (Sixteen Cases)

In this group, the average age was thirty-five years. The oldest patient was sixty-two, and the youngest was eighteen.

There was a sudden onset of back pain,—severe, constant, and, in the majority of cases, increasing in intensity and interfering with sleep; in some there was radiation of pain to the corresponding peripheral segments (chest, abdomen, or extremities). Local tenderness and muscle spasm were marked. All patients were toxic. Temperature elevation, high in all, had been present since onset of the disease in twelve patients; in three patients it appeared after two days, and in one after a week.

Leukocytosis was present, with white blood cells ranging from 12,000 to 35,000. The sedimentation rate was increased. Agglutination tests for Malta fever, typhoid, and paratyphoid fever were negative in all cases, as was the Wassermann reaction.

The blood culture was positive for non-hemolytic *Streptococcus* in one case, and positive for *Staphylococcus aureus* in six cases. It was positive for *Streptococcus viridans* in two cases and negative for this organism in two cases. In the remaining cases the record is not available, since these patients were not seen on this Service until after the acute stage.

Abscess formation appeared in twelve patients after intervals of from one to three weeks following the onset of the clinical symptoms. The diagnosis in these twelve cases was confirmed later, when smear, culture, and guinea-pig inoculation had ruled out all except the pyogenic micro-organisms. In ten of the cases with abscess, hemolytic *Staphylococcus aureus* was obtained; in one there was beta-hemolytic streptococcus; in another—with sinus formation on admission—both *Streptococcus viridans* and *Staphylococcus albus* were obtained.

In the remaining cases, without abscess formation, the diagnosis was based on the typical clinical course and the sequence of roentgenograms. Other peculiarities in favor of the diagnosis were as follows:

In one case the destructive process in the spine appeared three weeks after onset of a pyogenic infection of the patient's hand. On admission the blood cultures were positive for non-hemolytic streptococcus. All other tests were negative, except the tuberculin test. The vertebral lesion healed, and in seven months produced a solid block of two vertebral bodies. The patient has been completely free of symptoms for the past nine years.

In another patient, the vertebral lesion started three weeks after the healing of a suppurative mastoiditis, which had been draining for the previous two months. Tests for other conditions were negative. The spinal lesion healed in six months. The patient has been completely free of symptoms for the past seven and a half years.

Two other patients were admitted four weeks after the onset of the process. The history was typical of pyogenic spondylitis, and no other source of infection could be detected. According to the roentgenograms, the spinal lesion healed in from seven to eleven months; the observation time of complete cure has been five and nine years, respectively.

B. Subacute Osteomyelitis of the Spine (Seven Cases)

In these patients the toxaemia is mild. In three of these seven, the process started following serious pyogenic infections in other parts of the body (lesion of the upper lip, perinephritic abscess, pyogenic tenosynovitis). In all of these patients the tuberculin test was negative, as were all other skin and agglutination tests.

In another patient (M. F.—38-15120) the onset was insidious, with low temperature, backache of mild character, and formation of several abscesses, which clinically showed the characteristics of a cold abscess. Roentgenograms of the spine showed destruction accompanied by marked decalcification, and so the possibility of a tuberculous spondylitis was seriously considered. For these reasons, four guinea pigs were inoculated with the pus; all tests were negative. The agglutination tests and the fungus cultures were also negative. The only bacteria that could consistently be obtained from the pus were the beta-hemolytic streptococcus and the *Staphylococcus aureus*. One year later, the patient died, after progression of the infectious process, and the postmortem findings confirmed the diagnosis.

The remaining three cases constitute a subgroup that present special clinical and diagnostic problems,—the group with epidural abscesses. Cohen and Dandy have both written about the diagnosis of epidural abscess.

Infection of the epidural space occurred in our cases as a complication of osteomyelitis of the laminae. The diagnosis was made clinically in two of the cases. In one of these, a flaccid paralysis of the lower extremities developed, following elevated temperature, pain in the low back, and difficulty in voiding.

The other patient had a furuncle on his left forearm, and one month later the same clinical picture, characterized by back pain, slight temperature elevation, and difficulty in voiding, appeared. Two days later signs of meningeal irritation became evident. On admission, an emergency drainage of the back was performed. The patient died one month later. At necropsy, acute osteomyelitis of the laminae was found, with several abscesses in the epidural space from the thoracic to the lumbar region, in addition to multiple pyogenic foci in the pleura and kidneys. The culture showed hemolytic *Staphylococcus aureus*.

The following case presents the typical history, and constitutes a good example of the differential diagnosis between an epidural abscess and any other condition producing low-back pain.

Two weeks before admission the patient, while lifting a heavy load, felt a sudden, sharp pain in his low back. The pain became progressively worse, and during the following days it could not be controlled by strapping, traction, or morphine. Ten days later, difficulty in voiding developed, requiring catheterization. Physical examination on admission revealed tenderness over the spinous process of the third lumbar vertebra, marked limitation of motion of the lumbar spine, and marked muscle spasm. The patient was unable to stand, because of weakness in the lower extremities and tremor in his right foot. Neurological examination was otherwise essentially negative. For ten days the patient was kept in traction, but the pain became so severe that syncope occurred on one occasion. The daily temperature was 100 degrees, which was the same as that recorded on admission. There was slight leukocytosis; the roentgenograms were negative. During the next week the patient improved slightly; therefore conservative measures were continued. One and one-half months after the onset of the initial symptoms, the patient had a severe pain in his back with radiation down both legs. No relief was obtained by the use of morphine, and a laminectomy was performed. A typical epidural abscess was found at the level of the fourth lumbar interspace, secondary to an osteomyelitic process of the neural arch.

As far as the differential diagnosis between an epidural abscess and a chronic granuloma is concerned, our experience is based upon only one case of chronic granuloma, appearing in a patient with infectious spondylitis produced by Malta fever. In the granuloma the development of the process was slower, over a period of eight months, and the pain was not so severe.

Epidural abscess may be differentiated from neoplasm developing in the spine by the presence of temperature elevation and leukocytosis, and by the sudden onset and rapid development of the process. The growth of a neoplasm usually continues for a period of months instead of days.

C. Osteomyelitis of the Spine of Insidious Onset (Nineteen Cases)

These patients did not experience temperature elevation or other general reaction. In most cases the pain was very sharp and was not relieved by rest; it was more intense at night and was aggravated by coughing and sneezing. Radiation of pain was not a constant feature. Loss of weight was present in practically all of the cases.

The most constant physical findings were limitation of motion of the spine and the detection, either by palpation or percussion, of an area of localized tenderness. Roentgenograms showed the presence of a destructive process in the vertebral bodies of seventeen of the cases. In the other two cases, the destruction was limited to the neural arches.

In view of such a clinical and roentgenographic picture, other infectious processes should be taken into consideration. Typhoid and paratyphoid fever, Malta fever, mumps, and pneumococcus spondylitis can usually be ruled out by the clinical history, the agglutination test, and the skin test. However, the question: "Is this process a low-grade pyogenic or a tuberculous osteomyelitis?" arises almost daily.

In considering this question, we must separate the cases in which the infectious

process is localized exclusively in the neural arches, because these cases are practically always of pyogenic origin. Invasion of the posterior arches by the tubercle bacillus is uncommon. Anderson stated that up to 1940 there were only twelve cases of tuberculosis of the spinous process cited in the foreign literature; he reported the first case in the American literature.

Our two cases of insidious onset and course, with isolated destruction of the neural arches, were both proved to be osteomyelitis. Pus collected, with all the clinical symptoms of a cold abscess, several months following the onset of symptoms, and the cultures yielded *Staphylococcus aureus*.

Of the remaining seventeen cases of pyogenic spondylitis of insidious onset and evolution, affecting the vertebral bodies, the differentiation between pyogenic infection and tuberculosis was based on the following findings:

1. In four cases, pyogenic organisms were cultured from the pus of abscesses, with the clinical characteristics of cold abscesses, that appeared several months after the onset of symptoms.

2. In three cases, the destructive spinal condition appeared from two to three months after an intense pyogenic infection in some other part of the body.

3. In two cases, the patients had several active foci of osteomyelitis involving the extremities.

4. In five cases, the tuberculin test was consistently negative, in spite of being repeated several times at different concentrations.

5. In the remaining three cases, our diagnosis was justified by the following means: (a) Other infectious processes were carefully ruled out and (b) the series of roentgenograms showed a process identical in its course with that of proved cases of pyogenic osteomyelitis of the vertebral bodies.

With two exceptions, all the cases of this group have been observed for more than five years, during which time the patients have been completely free of symptoms and there has been no reason to change the diagnosis.

DIFFERENTIAL DIAGNOSIS OF PYOGENIC SPONDYLITIS FROM A ROENTGENOGRAPHIC POINT OF VIEW

In pyogenic infections affecting the neural arch, we have found involvement of the spinous articular and transverse processes, and of the laminae. The infections that involve the vertebral body may be either localized or diffuse. Each of these two possibilities presents different diagnostic problems.

Unfortunately there are no reliably characteristic roentgenographic findings for the different types of infectious spondylitis. As regards the diagnosis of spondylitis due to Malta fever, typhoid fever, mumps, or any other specific vertebral infection, it is necessary to rely mainly on the clinical history, the agglutination tests, the skin tests, and the blood findings in each case. In our cases we found that, after all the possibilities had been exhausted, the most frequent diagnostic problem was to differentiate between pyogenic and tuberculous spondylitis.

For the reasons just explained, forty-three cases of proved tuberculosis of the spine, with good roentgenographic follow-up and presenting initial lesions very similar to those encountered in the cases of pyogenic spondylitis, have been selected for comparison in this study.

Pyogenic Osteomyelitis Affecting the Vertebral Body

A. Localized Forms

In the localized forms of pyogenic infection of the vertebral body, the lesion was a small, circumscribed destructive area, situated close to the epiphyseal ring or the cartilaginous plate. A slight narrowing of the intervertebral disc was present in the first stages

of the process, accompanied by some atrophy of the bony tissue surrounding the focus of infection. Within an average of from four to six months some sclerosis appeared around the initial focus, and in some cases a slight reactive new-bone formation was visible as early as three months following the onset of symptoms. In our cases, the process healed within periods ranging from nine to twelve months. The roentgenographic follow-up of these patients for periods exceeding five years showed that the only residual abnormalities were irregularities in outline of the previously affected body, a thinning of the intervertebral disc, and, in some cases, a localized osteophytic formation.

FIG. 1

Roentgenogram showing notching of the inferior surface of the body of the third lumbar vertebra and of the upper surface of the body of the fourth lumbar vertebra. There was slight diminution of the intervertebral space.

There were eight cases of localized pyogenic spondylitis in our series. In two patients, the destructive process was initially located at approximately the center of the upper or lower surface of the vertebral body. One of these healed in six months, the only residual alterations being a thinning of the intervertebral disc and what appeared to be calcification of the nucleus pulposus that has been persistent for the last six years of observation. The

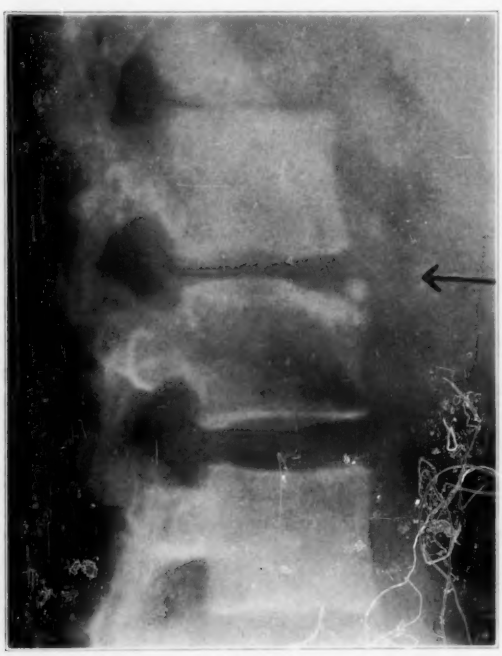

FIG. 2

Localized lesion in upper anterior border of the body of the third lumbar vertebra, two weeks after the onset of the clinical symptoms.

FIG. 3

Localized lesion in another case of proved osteomyelitis of the spine, five months after onset of the clinical symptoms.

other patient had a similar localization and evolution, the residual deformities being a notching of the upper and lower surfaces of the two contiguous vertebral bodies and a diminution of the intervertebral space (Fig. 1).

Ghormley, Bickel, and Dickson reported several similar cases and explained the etiology as infectious processes confined to the intervertebral disc. The fact that our two patients were boys ten and eleven years old, respectively, could be used as evidence in favor of this hypothesis.[20] It is difficult, however, to determine whether the notching of the vertebral surfaces in our second case was due to a primary osseous focus or was only a deformity secondary to an infectious process of the intervertebral disc.

In four cases the localized pyogenic focus was situated in the epiphyseal ring (Figs. 2 and 3). The patients were between two and fifteen years of age. In one of them we were able to recognize signs of new-bone formation one month after the onset of the clinical symptoms (Fig. 4). Gottlieb reported a similar case and explained the cause as an infectious process circumscribed at the annulus fibrosus. Freedman described a proved case in a fourteen-year-old girl, in which only the epiphyseal ring was involved. We have not observed any cases of the localized type in adults.

FIG. 4

Localized destructive lesion of the lower surface of the third lumbar vertebral body, four weeks after onset of the clinical symptoms. There is a decrease of the intervertebral space and reactive new-bone formation.

Another group of localized pyogenic infections was represented by two cases in which the process affected exclusively either the anterior or the lateral surface of one or several vertebral bodies. This was observed in patients with osteomyelitic involvement of the neural arches; when surgical drainage was performed, several abscess extensions were found directed toward the vertebral bodies. Such extensions were also found in an abscess spreading along the anterior surfaces of the contiguous vertebrae.

If these different types of lesions are considered from the point of view of the differential diagnosis, it will be observed that any one of them can be produced either by a pyogenic or by a tuberculous organism. It is not the shape of the lesion or its localization that makes it possible to differentiate between the two conditions. Only through careful study of roentgenograms taken at intervals over a considerable period of time will the differences in the progress of the two lesions make possible a differential diagnosis.

Fifteen cases of proved tuberculous epiphyseal spondylitis were studied for purposes of comparison. Similar to our pyogenic cases, during the early stages of the process they presented a progressive thinning of the intervertebral space, atrophy of the osseous tissue, decalcification, and, in some, a focus situated just below the epiphyseal plate. However, the evolution or progress of the two diseases was different. In the cases of osteomyelitis, the process lasted from nine to twelve months; in the tuberculous cases, the thinning of the disc progressed for periods averaging two to three years. In the pyogenic cases, diminution of the intervertebral space was only partial; in the tuberculous cases (due to longer duration of the process), the thinning progressed slowly, until both vertebral bodies came

FIG. 5

FIG. 6

Fig. 5: Epiphyseal type of proved tuberculosis three years after onset of a slow and progressive thinning of the intervertebral disc.

Fig. 6: Marked bone-bridging in a proved case of osteomyelitis of the spinous processes, laminae, transverse processes, and lateral surfaces of the vertebrae, due to *Streptococcus haemolyticus*. The bridging extends from the first to the fifth lumbar vertebra, the intervertebral spaces being preserved.

in close contact (Fig. 5). In pyogenic cases, reactive new-bone formation could be recognized as early as one to three months after the onset of symptoms; spur formation in the tuberculous type was minimal, late, or not present at all. Finally, the sclerosis around the primary focus was clearly visible early in the cases of pyogenic infection; in tuberculosis it was absent or of very mild intensity in the early stages.

The differential diagnosis in cases involving the anterior or lateral surface of the vertebral body depends upon the roentgenograms. In some cases of tuberculosis, there was a notching of the anterior surfaces with preservation of the intervertebral disc and cartilaginous plates; while in pyogenic infections, although the intervertebral spaces were preserved, the process had produced several spicules of new bone, easily detectable in the lateral view, or marked bone-bridging (Fig. 6).

B. Diffuse Forms

In these cases the process is not localized, but produces a diffuse pyogenic spondylitis. This occurred in thirty-two of our cases of pyogenic spondylitis. For differential purposes, we have compared them with twenty-eight cases of the central type of tuberculous spondylitis, of which good follow-up roentgenograms were available.

In pyogenic infections of the vertebral bodies, during the early and atrophic stages, a fuzziness of the limits of the upper and lower surfaces of the vertebral bodies could be observed, as well as a lessening in their density (Fig. 7-A). However, this isolated atrophy did not last long. As early as two months after the onset of symptoms, small spicules of reactive new-bone formation were observed. Eventually the atrophy was replaced by a dense sclerosis, present throughout the entire remaining portions of the bodies of the two contiguous vertebrae (Fig. 8-A). This sclerosis appeared as early as three months after the onset of symptoms, and persisted for periods ranging from three to six months. A solid bony block appeared at the termination of the period of sclerosis (Fig. 8-B). In one case,

FIG. 7-A

One and a half months after the onset of symptoms, the entire intervertebral space was involved.

FIG. 7-B

Four months after onset of symptoms.

with progressive spreading of the process, the atrophy persisted until the death of the patient, one year later.

On the other hand, the cases of infectious spondylitis, produced by the tubercle bacillus, presented marked atrophy for at least two years. This atrophy was rarely replaced by sclerosis, but usually by a clearer delineation of the structure and trabeculation of the vertebral bodies. Increase in density, in our recumbent tuberculous patients, was a transitory and mild phenomenon, except when it was due to the presence of sequestra or sudden collapse of the body, or when it occurred in cases with mixed infections. Block formation was a very late phenomenon, usually between four and six years after the onset of the clinical symptoms, and was prone to produce sudden collapse of the diseased vertebrae.

FIG. 7-C

One year after onset of symptoms.

Reactive new-bone formation, which was a rare phenomenon in the tuberculous cases, except in those of long duration, was seen in the lower segments of the lumbar spine, where calcification or ossification of the intervertebral ligaments was also evident.

Although there is no doubt that marked reactive bone formation does occur in certain cases of tuberculosis of the spine, it is rare. When it does occur, it is usually in the late stages of the process and is usually circumscribed at the lumbar spine. On the other hand, in the diffuse forms of pyogenic spondylitis, reactive new-bone formation is, as a rule, an early and marked phenomenon.

FIG. 8-A

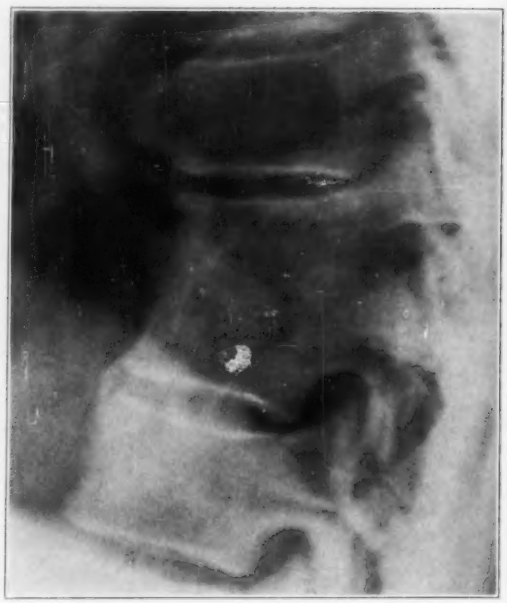

FIG. 8-B

Fig. 8-A: Complete involvement of the intervertebral space between the ninth and tenth thoracic vertebral bodies, seven months after the onset of symptoms. There is marked sclerosis of the involved vertebral bodies.

Fig. 8-B: Solid block one year after onset of symptoms.

Increased Roentgenographic Density in Cases of Tuberculous Spondylitis

It is erroneous to assume that areas of increased roentgenographic density cannot be observed in cases of tuberculous spondylitis. Aubry and Pitzen have called attention to the fact that in some cases there is an increase of the osseous density at the level of the pathological process, and they attributed this phenomenon to a process of trabecular penetration secondary to pressure. Later, Freund confirmed these findings in cases of tuberculous spondylitis with caseation, and explained them on the basis of the affinity that the caseous material has for the calcium salts.

Finder described the presence of sclerosis and sequestration in a case of healing tuberculosis of the spine, and believed that these conditions were due to the healing process. Compere and Garrison were able to confirm these findings only in cases of secondarily infected tuberculous spondylitis, and attributed Finder's observations to the fact that his specimen was obtained from a patient who had multiple abscesses and discharging sinuses.

More recently, Cleveland and Bosworth have called attention to the fact that there is a high incidence of sclerosis in human tuberculosis of the spine, due to a massive loss of blood supply. Auerbach and Stemmerman also found that, in the roentgenograms of hemisections of spines with productive tuberculous lesions, there were consistently present areas of increased density that, for lack of a better term, were referred to as areas of sclerosis.

In spite of all these descriptions, the fact remains that in tuberculosis of adults, areas of increased density are not frequently found in the roentgenograms of living subjects, with the exception of patients with secondary infection, huge sequestra, or sudden collapse. Areas of increased density are sometimes observed in children during the very early stages of the disease, or during the healing period.

This apparent paradox can be explained by the statement of Cleveland and Bosworth that, in most cases, the roentgenographic images fail to reveal the presence or full extent

of the condition. Although the roentgenograms of their pathological specimens showed either mottling or very definite sclerosis, the roentgenograms of the same patients, taken during life, showed definite sclerosis in only one case (Sea View Hospital, No. 11322). In another case (Sea View Hospital, No. 2797) the amount of sclerosis and calcification seen by roentgenogram, taken before death, was so slight that it escaped the notice of the authors.

The same discrepancy between the roentgenograms of living subjects and those of pathological specimens was emphasized by Bosworth in 1939. More recently, Auerbach and Stemmerman have reached similar conclusions.

Therefore, although increase of density and sclerosis in tuberculous spondylitis, as seen in the roentgenogram, is a phenomenon which it is difficult to observe in living subjects, in pyogenic spondylitis it is clearly visible, accompanied by spur formation and appearing after an atrophic period lasting from a few weeks to a few months. Consequently, it has great diagnostic value in differentiating between the two conditions.

As previously stated by Steindler, the cases of so-called tuberculous spondylitis, characterized in the roentgenogram by marked sclerosis and bone formation, should be observed with suspicion, as they may prove to be cases of chronic staphylococcic osteomyelitis.

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OSTEOCHONDROMATA OF THE PELVIC BONES

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While the generally accepted opinion is that osteomata and osteochondromata are benign lesions, it is recognized by those who have seen many of these lesions that they may sometimes be difficult to eradicate surgically, and at times may apparently become malignant and terminate fatally. This is particularly true of lesions involving the bones of the pelvis. When such a tumor has a definite pedicle, and complete surgical removal can be carried out, the prognosis is good. On the other hand, many of these tumors, particularly those arising in cancellous bone, are not well pedunculated, and complete surgical removal is difficult. The extent of involvement of cancellous bone by chondromatous tissue is often difficult to determine, because the roentgenogram does not reveal its extent, and about the only way to determine the presence of chondromatous tissue is by examination of microscopic section. Lesions on the inner surface of the pelvic bones may be almost completely inaccessible by any type of conservative surgical procedure.

The symptoms which cause the patient to seek relief are pain, swelling, and deformity. In some instances, however, no symptoms are present and the lesion is discovered accidentally when roentgenograms are made for some other reason. Pain may have persisted for several years before the true nature of the condition is discovered. In some cases, in which for various reasons surgical removal has not been accomplished, the tumors have grown to huge size, and the patient has suffered intense pain for many years.

Meyerding [1] has reported the removal of 265 exostoses from 232 patients. The known duration of the condition varied from a few days to thirty-five years; the average duration was four and one-half years. Eighty per cent. of the patients were between the ages of eleven and forty years. In 39 per cent. there was a history of trauma, although in many cases the injury caused recognition of a pre-existing condition. Four of the patients stated that the condition was familial. Of the pelvic lesions, fourteen were situated in the ilium, four in the pubis, and two in the ischium. In 10 per cent. of the cases, the osteochondromata recurred after they had been removed surgically.

MATERIAL

The present paper is based on a study of forty patients with osteochondroma of the innominate bone, upon whom operation was performed at the Mayo Clinic during the years 1910 to 1943, inclusive. In each case the diagnosis was verified by microscopic examination. Twenty-six of the patients were males, and fourteen were females. Their ages ranged from four to sixty-two years; the average age was thirty-three and one-half years. Three of the patients had multiple congenital exostoses.

CLINICAL DATA

In thirty-seven patients, the duration of symptoms varied from one week to twenty-one years, averaging three and one-half years. In the other three, the tumor was discovered incidentally. The initial symptoms were as follows: A mass was discovered in seventeen patients, pain in thirteen, a limp in one, a weak leg in one, urethral discharge in one, a slow urinary stream in one, a limp and "tired" hip following injury in one, and a limp and an ache following "poliomyelitis" in childhood in one. The original symptom was not recorded in one case.

In six patients, trauma had preceded the onset of symptoms. The interval between the injury and the onset of symptoms varied from one to sixteen years; the average interval was four and one-half years. Three other patients said that an injury had occurred at the time the symptoms had begun.

At some time during the course of the disease, twenty-eight patients had experienced pain or discomfort; this was described as tenderness to pressure, an ache, or a severe pain. Two patients complained of pain which did not seem to be related to the tumor. Twenty-one patients had noted a mass or a prominence. In one case the tumor had been discovered by the family physician. In two cases the tumors were found during childbirth, and in two cases they had been discovered by roentgenographic examination. Fifteen patients stated that the mass had increased in size. A limp was recorded in seven cases. One patient (Figs. 1-A and 1-B) complained of a urethral discharge, and another (Figs. 2-A and 2-B) complained of both a slow urinary stream and a progressive decrease in the size of his stools.

The location of the tumors is shown in Table I. The primary lesion was intrapelvic in ten cases; in five cases, the recurrent lesions were intrapelvic. The right side was involved in sixteen cases, and the left in twenty-four cases.

TABLE I

SITE OF INVOLVEMENT

	Number of Cases
Ilium	
Anterior superior spine	10
Crest and wing	7
Posterior spines	4
Acetabular region	3
Too large to localize	4
Pubis	8
Pubis and ischium	3
Ischium at acetabulum	1
Acetabulum and femur	1
Total	41 *

* One patient, who had multiple congenital exostoses with lesions of ilium and pubis, is included twice.

In twenty-six cases, roentgenographic examination did not disclose evidence of metastatic involvement of the thorax, and in one case the presence of such involvement was questionable. In the remaining thirteen cases, no mention was made of metastatic involvement of the thorax.

TREATMENT AND RESULTS

Sixty-nine surgical procedures were carried out on the forty patients (Table II). In one patient, twelve operations, in addition to cauterization, were performed in twenty-three years. Eleven attempts were made to excise the tumor, and on another occasion a sinus was curetted. Five operations were performed on one patient; three operations were performed on three patients; two operations were performed on four patients; and one operation was performed on twenty-eight patients. In two cases, excision was performed in two stages. In eight cases, cauterization was applied after the first procedure. In five of these cases, the tumor had not recurred when the patients last were heard from. The tumor had recurred in two cases, and follow-up data could not be obtained in the remaining case.

Table III shows the diagnoses based on microscopic examination. In the first case listed, the patient apparently was well eight years after the last operation. In the second case, the patient died five months after the last operation. When follow-up data last were obtained in the third case, the condition of the patient was becoming worse. The fourth patient died thirteen months after the last operation. The fifth patient died of a recurrence, four years after the last operation. The sixth patient underwent another operation after he left the Clinic. In the seventh case, a recurrent tumor was removed ten months after the first operation. When follow-up data last were obtained in the eighth case, the condition

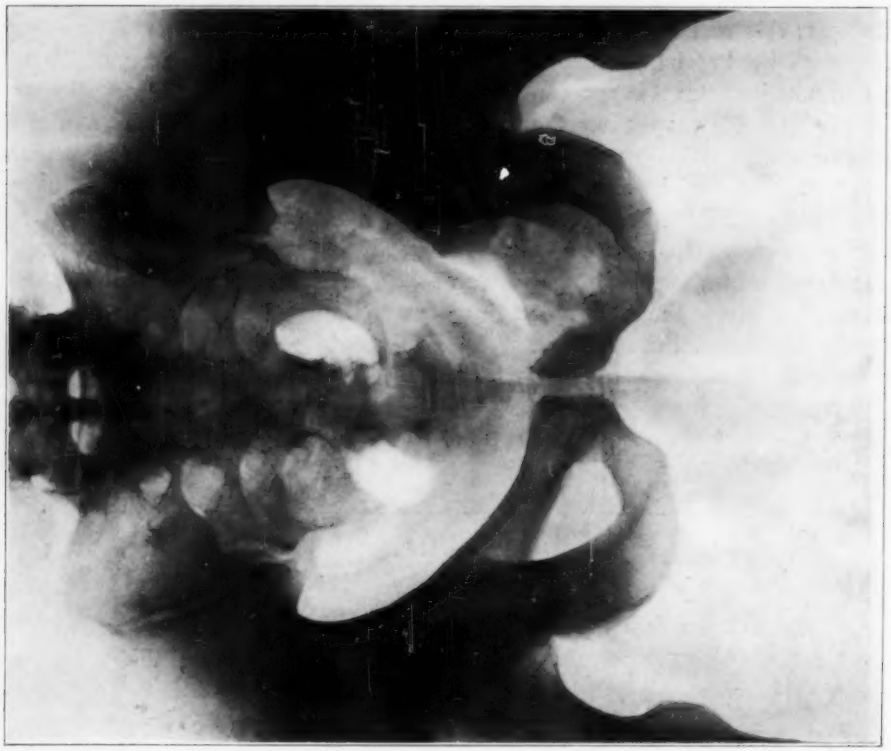

FIG. 1-B
One month after removal of the tumor.

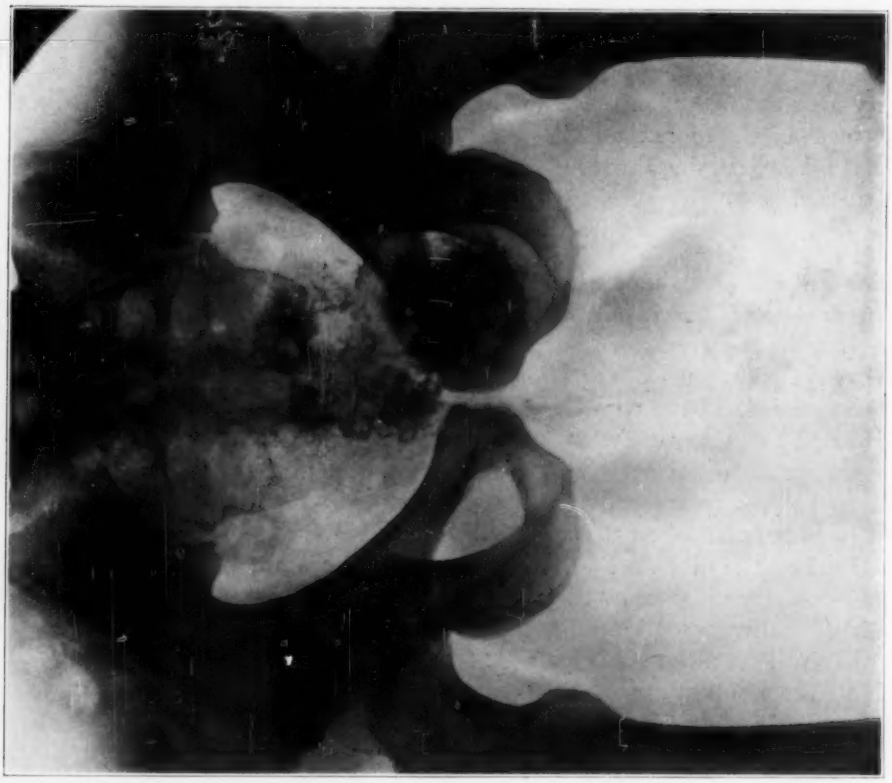

FIG. 1-A
Roentgenogram showing osteochondroma which had caused a urethral discharge.

One month after removal of the tumor.

FIG. 2-A

Roentgenogram showing osteochondroma that had caused slowing of the urinary stream and a decrease in the size of the stools.

FIG. 2-B

Recurrence of tumor eleven months after operation.

TABLE II

SURGICAL PROCEDURES CARRIED OUT ON PATIENTS WITH OSTEOCHONDROMATA

Procedure	Times Procedure was Performed in Respective Cases	Number of Cases	Number of Procedures Performed in Respective Cases
Excision	12	1	13
Cauterization	1		
Excision	5	1	5
Excision	3	3	9
Excision	2	4	8
Excision in stages	2	2	4
Excision	1	1	2
Partial excision	1		
Excision	1	22	22
Partial excision	1	4	4
Biopsy	1	2	2
Total		40	69

of the patient had become worse. In the ninth case (Figs. 3-A, 3-B, and 3-C) the tumor had not recurred ten months after the last operation. The weight of the tumor, which was recorded in twenty instances, was between 20 grams and 2,850 grams.

Some observers believe that, once incompletely removed, many, if not all, of these tumors tend to become more active in their growth and ultimately to become malignant. We cannot prove this to be consistently true from the facts revealed in this review. In the first case in Table III, the condition was twice diagnosed as sarcoma on microscopic examination, but nine times as a benign lesion. The fact that the patient was well eight years after the last operation would leave doubt about the presence of a malignant lesion.

Eleven patients received postoperative irradiation therapy. In seven of these cases, roentgenotherapy was employed; in two, radium therapy was employed; and in two, both radium and roentgenotherapy were used.

TABLE III

DIAGNOSES BASED ON EXAMINATION OF PATHOLOGICAL SPECIMENS

Diagnosis	Number of Times Diagnosis was Made in Respective Cases	Number of Cases
Chondrosarcoma	2	1
Inflammation	2	
Osteochondroma	7	
Osteochondroma	1	1
Mixed-cell sarcoma	1	
Osteochondroma	5	1
Osteochondroma	2	1
Chondromyxosarcoma	1	
Myxochondroma	1	1
Osteomyxochondroma	1	
Osteochondroma	3	1
Osteochondroma	2	1
Cellular chondroma or malignant osteochondroma	1	1
Chondroma	1	1
Recurrent cellular chondroma	1	
Osteochondroma	1	20
Chondroma	1	6
Degenerating osteochondroma	1	3
Degenerating chondroma	1	1
Myxochondroma	1	1
Total		40

In two of the seven patients receiving roentgenotherapy, the only surgical procedure prior to this treatment was the removal of tissue for biopsy. One of these patients has died, and the other underwent a subsequent operation. In the third case, the tumor was partially removed; two courses of postoperative roentgenotherapy were given at the Clinic, and two courses were given elsewhere. The patient was reasonably comfortable when last heard from, thirty-three months later. In the fourth case, we gave a second course of postoperative roentgenotherapy after it had been employed elsewhere, but the patient died. In two other cases in which postoperative roentgenotherapy was employed, the patients also have died; in one, roentgenotherapy was

FIG. 3-A
Chondroma of right ilium.

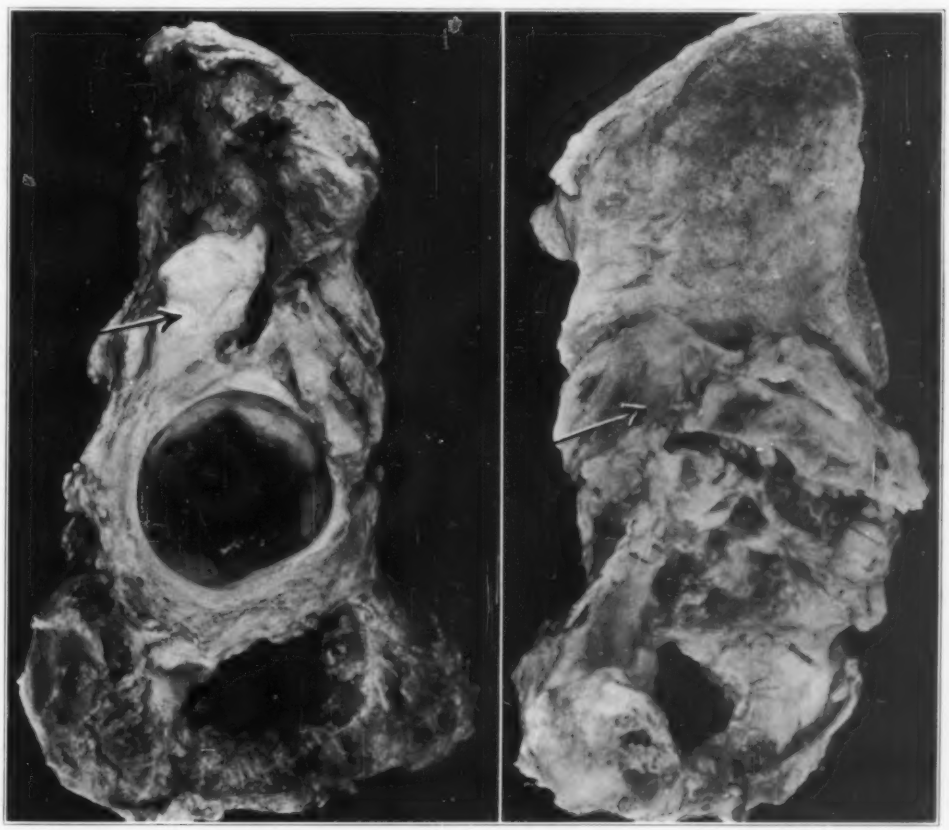

FIG. 3-B
Outer surface of innominate bone.
(Arrow indicates chondroma.)

FIG. 3-C
Inner surface of innominate bone.
(Arrow indicates chondroma.)

employed after three unsuccessful attempts to remove a lesion that proved to be malignant. In the seventh case, the patient was well ten years after discharge from the Clinic.

In one case in which radium therapy was employed, the patient has died. In the other case, radium therapy was employed after the removal of a recurrent tumor. When the patient returned to the Clinic on two occasions during the next year, there was evidence that the tumor had recurred; however, eleven years later the patient was well, and stated that he had not observed any evidence of recurrence of the tumor.

In one of the two cases in which both types of irradiation treatment were employed, the tumor recurred; in the other case, the patient has died.

The value of roentgenotherapy or radium therapy in these cases seems doubtful. There was only one case in which it may have done any real good.

One patient, who has undergone three operations since leaving the Clinic, subsequently returned with metastatic involvement of the thorax. Another patient has had two operations since he left the Clinic. Two patients were given irradiation therapy elsewhere after they had been operated upon.

Nine, or 22.5 per cent., of the forty patients are known to have died. Their symptoms had been present for from nine months to twenty-one years before the patients first were operated upon at the Clinic; the average duration was five and one-half years. In seven of these cases, the patients lived for from one to six years after they were operated upon; the average period of survival was 3.3 years. The date of death of one of the two remaining patients is unknown; the other died of operative shock.

It must be noted that we do not have necropsy findings to determine the true nature of the lesions. If such findings were available, they might show malignant changes in several of these patients.

Eight, or 20 per cent., of the patients in this series were living when the last follow-up data were obtained, but their tumors had recurred. Symptoms had been present for from five months to ten years before the patients first were operated upon; the average duration of symptoms was 3.8 years. The period covered by the follow-up study varied from ten months to twenty-one years, averaging seven years. A little more description is given of five of these cases, to indicate the conditions encountered. In one patient there was evidence of a recurrence of the tumor on each of two occasions on which he returned within a year after operation; but in a letter received recently, twenty years after the operation, the patient reported that he was well. A second patient, in whom postoperative roentgenographic examination disclosed a fragment of osseous tissue, returned for a check-up thirteen years later. At this time, the fragment apparently was increasing in size. In a third patient, two operations had been performed elsewhere in 1937 and 1938, three were performed at the Clinic in 1939 and 1940, and two were performed elsewhere in 1942 and 1943. In a fourth patient an attempt was made to remove the tumor in 1939; the patient reported by letter in 1943 that his symptoms had returned. Another patient, who had been operated upon elsewhere in 1938 and upon whom we performed extirpation in 1940 and rhizotomy in 1941, was still living, although bedfast, in 1943.

In two, or 5 per cent. of the forty cases, not all of the tumor was removed. One of these patients is still living, sixteen years after the operation. The other patient was having "little trouble" when last heard from, thirty-three months after the operation.

Recurrence of the tumor cannot be regarded as a sign of malignancy. It has been pointed out that thorough and complete removal of these tumors is at times very difficult. If removal is incomplete, recurrence is sure to follow, although not necessarily as the result of malignant degeneration.

No follow-up data were obtained on six (15 per cent.) of the forty patients. One of these patients was operated upon in 1940, and the other five in 1943. In one case, operation was performed solely to obtain material for biopsy.

In fifteen, or 37.5 per cent., of the cases, there was no evidence of recurrence when the

patients last wrote or were seen at the Clinic. The interval between the last operation and the time the last follow-up data were obtained varied from six months to sixteen years, averaging 6.7 years. This group includes the patient upon whom thirteen operative procedures were performed, five patients who received cauterization, one patient who received postoperative irradiation, and one patient upon whom an interinnomino-abdominal (hindquarter) amputation was performed for a recurrent chondroma (Fig. 3-A). Ten months after the amputation the patient reported that he was well.

Definite malignant changes were not found at the first operation, but were ultimately found in the lesions of four, or 10 per cent., of the patients. In one case a diagnosis of osteochondroma was made at the first operation, and a diagnosis of mixed-cell sarcoma was made at the second operation, ten months later. In another patient, three surgical procedures had been performed elsewhere, and a diagnosis of chondroma was made at the time of operation at the Clinic. Three more operations were subsequently performed elsewhere. The patient then returned, and roentgenographic examination revealed a local recurrence and metastatic involvement of the lung. The third case was diagnosed as osteochondroma, and operations were performed. A diagnosis of chondromyxosarcoma was made at the time of the third operation. In the fourth case, biopsy was performed and the tissue was diagnosed as chondroma. The patient died a year later, however, and sections sent to us of lesions in the pelvis, lungs, and omentum disclosed fibromyxochondrosarcoma, Grade 3, according to the classification of Broders.

These four cases are the only ones in which an original microscopic diagnosis of chondroma was made, to be followed later by a diagnosis of some type of malignant tumor. It might be argued that in many such cases the tissue would present the picture of benign chondroma in some places, but definite malignant changes might be seen elsewhere. Proof of the actual mutation of the tumor from a benign to a malignant status cannot be given.

In addition to these forty cases, sixteen patients were observed during the same period (1910 through 1943) in whom malignant chondromatous lesions of the pelvis were present when the patients first were operated upon at the Clinic. In another case, examination of a specimen which was sent to the Clinic disclosed a malignant lesion. The type of malignant lesion was as follows: chondrosarcoma in nine cases, osteochondrosarcoma in two cases, osteochondromyxosarcoma in two cases, sarcoma in one case, fibrochondrosarcoma in one case, and fibromyxochondrosarcoma in two cases.

Twelve of these seventeen patients have died. The period of survival after operation at the Clinic varied from one and one-half to sixty months; the average period was 13.6 months. The duration of life from the onset of symptoms varied from five to ninety-six months; the average duration was 28.4 months.

Five of the seventeen patients were living when information about them was last obtained. One patient, who had had symptoms for five years before operation, wrote that he was in "perfect health" 6.25 years after removal of a chondrosarcoma, Grade 1. Another patient, who had had symptoms for two years before operation, was feeling well when seen again at the Clinic, five years and three months after the removal of a chondrosarcoma, Grade 1. A third patient had had symptoms for three years, and biopsy revealed a chondrosarcoma, Grade 2. This patient was living, but unable to walk, four years later. A fourth patient, after having had symptoms for five years, underwent an interinnomino-abdominal (hindquarter) amputation for chondrosarcoma, Grade 1. Seven months later he reported that he had gained twenty-five pounds. One patient, who had had symptoms for eight years prior to the removal of a chondrosarcoma, Grade 2, reported that he was in "excellent health" eighteen months later.

SUMMARY AND COMMENT

This study is based on forty cases of osteochondroma observed at the Mayo Clinic from 1910 to 1943, inclusive. In each case, the diagnosis was verified by microscopic

examination. A total of sixty-nine operations were performed on these patients. Nine of the patients are known to have died, and eight are known to have had one or more recurrences. In two cases, not all of the tumor was removed at the time of operation. In fifteen cases, there was no evidence of recurrence when the last follow-up data were obtained. No follow-up data were obtained in six cases.

In four of the forty patients, definite malignant changes were later found in the lesions. In sixteen patients (not included among the forty), microscopic examination revealed that the lesions were malignant at the time the patients were first operated upon at the Clinic.

From the foregoing review, the complexity of this problem is obvious. Chondromata of the pelvis must always be considered as serious surgical lesions. This is particularly true of those that are not well pedunculated, and of those in the more remote and inaccessible parts of the pelvis. When the tumor is purely cartilaginous in nature, the diagnosis may be extremely difficult. We have seen at least two cases in which the symptoms were referable to the hip, and, in spite of biopsies with negative findings, the symptoms continued and ultimately a chondroma was revealed. If the tumor is on the inner side of the innominate bone, particularly if it is within the true pelvis, its complete local removal is often difficult or impossible.

The idea is prevalent that these tumors may go from a benign to a malignant status, and in many cases this would seem to be true. However, in some of the cases described this change has not taken place, in spite of several recurrences and operations. In other instances, the presence of both benign and malignant regions in the same tumor may explain the apparent discrepancy.

The importance of complete surgical removal is evident to any one who has seen one or two of these patients in the late stage, when the tumor has reached a huge size, with a great deal of pain and discomfort, and there is little to offer in the way of relief. In those instances in which such removal cannot be accomplished by local excision, interinnomino-abdominal (hindquarter) amputations may be indicated.

1. MEYERDING, H. W.: Exostosis. Radiology, **8**: 282–288, 1927.

LATE RUPTURE OF EXTENSOR POLLICIS LONGUS TENDON FOLLOWING COLLES'S FRACTURE

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Spontaneous rupture of the tendon of the extensor pollicis longus muscle is always rare, but when such a rupture occurs late, following a Colles's fracture, it is even more unusual. In 1936 the writer saw a patient with a Colles's fracture, in whom a spontaneous rupture of the extensor pollicis longus tendon subsequently developed. Since that time he has seen four similar cases on the Fracture Service of the Presbyterian Hospital, New York City, and subsequently has operated upon all of these patients. In view of the rarity of this complication, and the disability that ensues unless the tendon is operated upon, these five cases are reported in some detail, as to incidence of occurrence, etiology, types of operative repair, and the end results. A brief survey of the literature on the subject is also included.

CASE REPORTS

CASE 1. K. H., a housewife, aged sixty-five, was first seen on May 11, 1936, eleven days after she had sustained a Colles's fracture of the left wrist. The fracture had already been reduced and splinted. Roentgenographic examination revealed good reduction, with mild dorsal comminution of the lower end of the radius (Fig. 1). On the twenty-sixth day after injury, the patient complained of pain in the dorsum of the wrist, following an injury on a bus the previous day when her purse jerked on this thumb. She was unable to extend her thumb. Examination disclosed no alteration in the alignment of the bones, but there was complete lack of power of extension in the distal phalanx of the thumb. Extension of the other fingers was normal. There was no loss of sensation in the radial-nerve distribution.

At operation on June 4, the extensor pollicis longus tendon was found to be ruptured. The distal end of the tendon was sutured to the tendon of the extensor carpi radialis longus. The thumb was immobilized in extension for two weeks, and then active exercises were begun. After three weeks the thumb no longer drooped, and the patient could actively extend the distal phalanx. When last seen, five months after operation, she had full use of the thumb and hand. Abduction of the thumb was complete; extension was twenty-five per cent. of normal; and flexion was complete without pain. In spite of the lack of full extension of the thumb, the patient was able to get it away from the side of her hand, which she could not do prior to operation. She had no power to elevate the thumb dorsally to the level of the remaining metacarpals.

CASE 2. I. M., a thirty-year-old cook, was first seen on January 19, 1938, one day after she sustained a Colles's fracture of the left wrist. Roentgenographic examination showed a fracture, with impaction and dorsal angulation (Fig. 2). The fracture was reduced and immobilized in a sugar-tong molded splint for five weeks, followed by hot soaks and frequent active exercises. One week later the

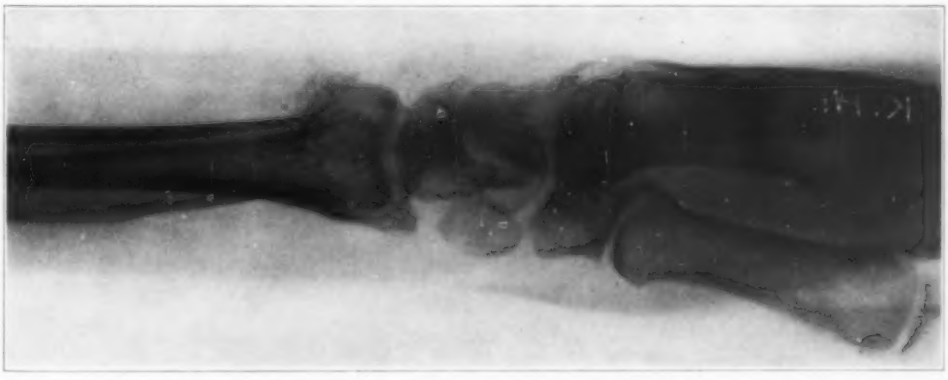

FIG. 1

Case 1. Lateral roentgenogram of left wrist after reduction of fracture.

FIG. 2

Case 2. Lateral roentgenogram of left wrist, showing fracture, with impaction and dorsal angulation.

patient noted weakness in her thumb and inability to extend it, but she did not return to the Fracture Clinic for another seven weeks. Examination showed that the patient was unable to extend the distal phalanx of the thumb, although abduction and extention of the proximal phalanx were possible. The entire thumb drooped, and she could not raise it toward the dorsum of the hand.

At operation on April 25 (seven weeks after rupture), the distal end of the ruptured extensor pollicis longus tendon was sutured to the tendon of the extensor pollicis brevis. The thumb was immobilized in extension for three weeks, and then hot soaks, active exercises, and massage were started. Seven weeks after operation, ability to flex and extend the distal phalanx actively was good. Seventeen months after operation these motions were still good, although extension was slightly weak. The patient was able to carry on full work as a cook, and noted only slight difficulty in lifting heavy pots. She was not able to elevate the entire thumb dorsally to the level of the other metacarpals quite as well as on the right hand.

CASE 3. M. W., a housewife, aged forty-six, was first seen on February 16, 1939, nineteen days after sustaining a fracture of the right wrist. She had received no treatment other than hot soaks. Roentgenographic examination revealed a mild deformity, typical of a Colles's fracture (Fig. 3). No reduction was performed, but the patient was advised to continue with soaks and to start frequent active exercises and mild use. On the following day, while exercising, she felt a "snap" in the wrist, followed by pain and inability to extend the thumb. Examination showed that the right thumb drooped; she was unable to extend the tip against resistance and could not elevate the thumb toward the dorsum of the hand. A loose nubbin was felt on the ulnar side of the antomical "snuffbox", which was thought to be the end of the ruptured extensor pollicis longus tendon. Radial-nerve sensation was normal.

At operation, the day after rupture, the distal end of the extensor pollicis longus tendon was su-

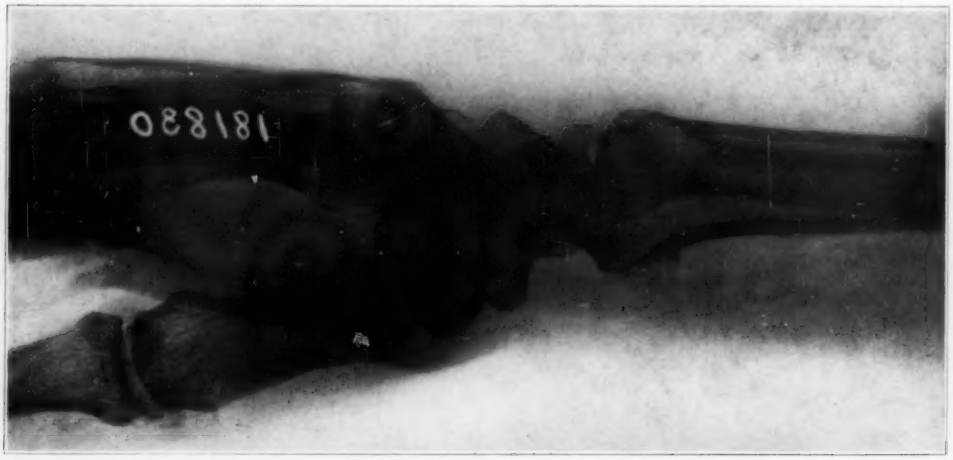

FIG. 3

Case 3. Lateral roentgenogram of right wrist, showing mild deformity.

tured to the extensor pollicis brevis and the abductor pollicis longus tendons. After immobilization in a molded plaster splint for twenty-three days, active exercises and soaks were given. Four weeks after operation the patient sustained a fracture of the radial styloid in the same wrist, but the tendon repair was not harmed. Two months after operation she could touch the middle of her fifth finger with the thumb, but extension of the thumb was not good. At thirteen months she had complete use of the wrist and thumb. When last seen, almost six years after operation, extension of the distal phalanx was full and strong. Dorsal elevation of the thumb was fifty per cent. of normal. The patient does housework with no handicap except difficulty in picking up pins and other small objects.

Case 4. M. M., a waitress, twenty-one years of age, was first seen on May 26, 1939, two months after sustaining a Colles's fracture of the left wrist. Deformity was so mild that she had not previously sought treatment. One month after the injury, she noticed inability to raise or straighten her left thumb, and there was slight pain at the base of the thumb. Examination revealed that the left thumb drooped, and the patient was unable to extend either the thumb as a whole, or the distal phalanx, against resistance, or to elevate the thumb toward the dorsum of the hand. Roentgenographic examination showed a healed Colles's fracture with minimal deformity (Fig. 4-A). The lower end of the extensor pollicis longus tendon could be felt and moved around beneath the skin by the examiner's finger.

At operation on June 18, the distal end of the ruptured extensor pollicis longus tendon was sutured to the extensor carpi radialis longus and the extensor pollicis brevis tendons. The thumb was immobilized for four weeks in a molded splint, but, beginning eight days after operation, this was removed three times daily for soaks and exercises. At seven weeks the patient had excellent active flexion and extension of the distal phalanx, and could abduct, extend, and elevate the thumb well. She returned to work at this time. Five and one-half years after operation, the patient's only complaint was slight pain in the region of the repaired tendon after protracted use. Active extension of the distal phalanx was full and powerful. She could elevate the thumb dorsally almost as well as its fellow, and could

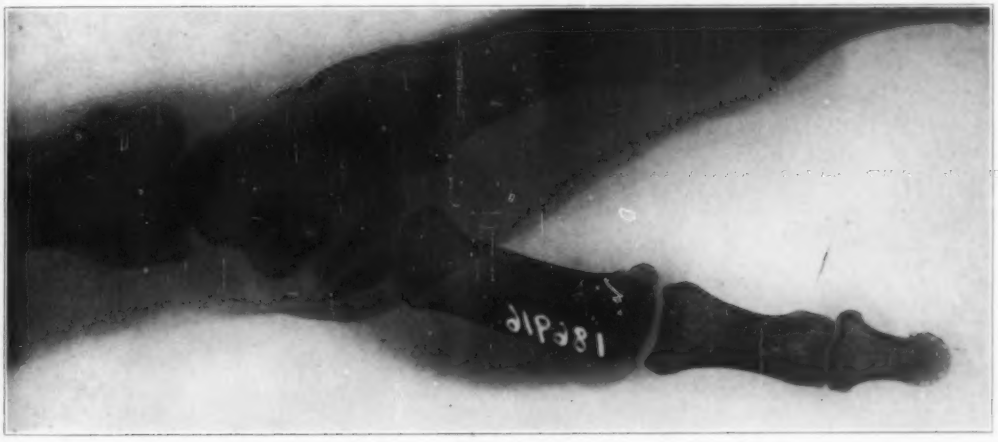

Fig. 4-A

Case 4. Lateral roentgenogram of left wrist, showing healed fracture.

Fig. 4-B Fig. 4-C

Both hands, five and one-half years after operation. Note full extension and dorsal elevation of left thumb, as compared with normal side.

touch the base of the fourth finger with it. Picking up pins caused slight difficulty. The patient now runs a sewing machine in a factory, with only slight handicap (Figs. 4-B and 4-C).

CASE 5. I. M., a factory worker, aged fifty-five, was first seen on July 10, 1943, one hour after she sustained a Colles's fracture of the left wrist. Roentgenographic examination revealed slight dorsal tilt, displacement, and radial deviation of the distal radial fragment (Fig. 5-A). The fracture was reduced, and immobilized in a sugar-tong plaster splint for twenty-six days. At this time, while exercising her

FIG. 5-A

Case 5. Lateral roentgenogram of left wrist immediately after fracture.

FIG. 5-B

Both hands in pronation prior to operation. Note visible absence of extensor pollicis longus tendon in left wrist.

FIG. 5-C

Both hands in mid-rotation prior to operation. Note drooping of left thumb and ill-defined snuffbox.

FIG. 5-D

FIG. 5-E

Both hands, thirteen months after operation. Extension of distal phalanx of thumb is complete, but power of dorsal elevation of entire thumb has been only partially corrected.

wrist and fingers, the patient felt a "snap" in her thumb and was unable to extend it thereafter. Examination three days later showed complete loss of action of the extensor pollicis longus tendon, with inability to extend the tip of the thumb or to elevate it dorsally (Figs. 5-B and 5-C).

At operation, seventeen days after rupture, the distal end of the ruptured extensor pollicis longus tendon was sutured to the extensor pollicis brevis and the extensor carpi radialis longus tendons. The thumb was then immobilized in full extension for twenty-two days; this was followed by soaks and exercises, and, at the end of four weeks, by light use. The patient could touch all finger tips with the thumb at the end of five weeks, and could elevate the thumb nearly to the level of the other metacarpals. She returned to work at the end of two months. Thirteen months after operation, extension of the distal phalanx of the thumb was complete, and ability to elevate the thumb dorsally was about fifty per cent. of normal. Abduction and adduction of the thumb were normal. The patient was carrying on her regular work in a factory (Figs. 5-D and 5-E).

REVIEW OF THE LITERATURE

McMaster, in 1932, reported a case of late rupture of the extensor pollicis longus tendon following Colles's fracture, and was able to find only twenty-seven similar cases mentioned in the literature. He also discussed a case of late rupture of the flexor pollicis longus tendon after Colles's fracture, which was the only case of its kind reported. This excellent article gives a very good historical review of the subject and a very complete bibliography. Lapeyre collected fifty-one cases of rupture of the extensor pollicis longus tendon in the literature, thirty-nine of which had followed fracture of the lower extremity of the radius (probably Colles's fracture). Kwedar and Mitchell found seventy cases in the literature, and added one case of their own which followed Colles's fracture. The first case was reported by Duplay in 1876. In the German literature are found a great many reports of spontaneous rupture of the extensor pollicis longus tendon, not preceded by fracture of the lower radius, which occurred in drummer boys in the army. This condition at first was known as "*Trommlerlähmung*", or drummer's palsy; it remained for Düms to show that it was not a palsy, but a spontaneous rupture of the extensor pollicis longus tendon due to chronic tenosynovitis, caused by this particular occupational trauma. So-called drummer's palsy is probably the commonest cause of rupture of this tendon, if industrial accidents, such as lacerations, are excluded.

ETIOLOGY

The etiology of rupture has not been definitely established, but it probably follows rather late after acute or chronically repeated trauma. The trauma causing the fracture could, by producing a spicule of bone, bring about partial laceration of the extensor pollicis longus tendon in its groove on the dorsum of the radius. A certain amount of bony comminution is frequent on the dorsal aspect in Colles's fracture, and a sharp fragment might easily cause chronic trauma and attrition as the tendon rubs back and forth over it. Forceful reduction of the fracture could conceivably be another cause of trauma to this tendon, but numerous cases of rupture have been reported where the fracture was minimally displaced or unrecognized, and no reduction had been done (Table I). Interference with the blood supply of the tendon (via the mesotendon) has been considered by many as the chief cause of late rupture. At the time of fracture, or shortly thereafter, the mesotendon is lacerated and its vessels may become thrombosed. The tendon at this site undergoes aseptic necrosis which causes softening, swelling, and gradual loss of strength, until such time as a slight sudden strain causes it to rupture. McMaster has shown experimentally that a normal tendon does not rupture under severe strain, unless it has been lacerated halfway through its substance. He also showed that late ruptures could be brought about by strain at the site where the blood supply to the tendon itself had previously been shut off by ligation of the tendon at two points, one centimeter apart. Diseased tendons frequently undergo spontaneous rupture, due to tuberculous tenosynovitis, gonorrheal tenovaginitis, or chronic non-specific tenosynovitis, as in "drummer's palsy". It is

TABLE I

RUPTURE OF EXTENSOR POLLICIS LONGUS TENDON

Case No.	Dorsal Comminution at Fracture Site	Fracture Reduction	Occurrence of Rupture in Relation to Use of Splint		
			During Use	After Discard	No Splints Used
1	Slight	Done	x		
2	Moderate	Done		x	
3	Absent	Not Done			x
4	Absent	Not Done			x
5	Slight	Done	x		

the writer's belief that, in rupture following Colles's fracture, the cause is an aseptic necrosis, due to interference with the blood supply of the tendon at the distal end of its groove on the radius. The operative and pathological findings in the five cases presented here would seem to bear out this assumption.

SYMPTOMS

There are no symptoms prior to rupture which would lead the surgeon to suspect a degenerative process in the tendon. Even when the tendon ruptures, not all patients give a history of pain. A few describe a single sharp pain, but most describe what they call a sensation of "something giving way", or a "snap" on the back of the wrist, followed by inability on their part to straighten or to lift the thumb actively, as compared with the normal thumb. They may also note difficulty in picking up small objects, such as pins. No subjective sensory changes are noted.

PHYSICAL SIGNS AND DIAGNOSIS

Physical examination reveals, first, a thumb that droops in its entirety, and, second, partial flexion of the distal phalanx. There is a normal droop to every thumb when the hand is examined in repose. With an intact extensor pollicis longus tendon, however, the patient can actively elevate the thumb to the same level as the other metacarpals or even higher; with a ruptured tendon this is impossible. It is also impossible for him to extend the distal phalanx actively against resistance, although this can be done passively. Therefore, one can easily understand how the early German writers considered the condition occurring in drummers to be a palsy. The inability of the patient to extend the distal phalanx of the thumb, in the presence of a ruptured tendon, has been noted by all writers on the subject, but few have described the tendency of the thumb as a whole to droop. When the normal hand is opened fully, and an attempt is made to spread the thumb and all fingers widely apart, the taut tendon of the extensor pollicis longus can very readily be visualized and palpated as the ulnar border of the anatomical snuffbox. With a ruptured tendon, this boundary is characteristically absent. Occasionally the swollen, degenerated end of the distal portion of the ruptured tendon can be felt beneath the skin and subcutaneous tissue as a small bump, often described as a nubbin. There is no loss of skin sensation over the superficial radial-nerve distribution. A paralysis or palsy of the posterior interosseous (deep radial) nerve would, of course, make it impossible for the patient to extend the second to the fifth fingers, inclusive, at the metacarpophalangeal joints, and would also affect extension of the thumb. Therefore, the diagnosis should not be difficult, if one keeps in mind that late rupture of the extensor pollicis longus tendon may occur many weeks after Colles's fracture.

SITE OF RUPTURE

The site of rupture in the extensor pollicis longus tendon is usually at the level of Lister's tubercle, on the dorsum of the lower extremity of the radius. The distal portion of the ruptured tendon is usually drawn downward, and may even be doubled back on itself. It is completely relaxed, and therefore does not stand out prominently as the ulnar border of the anatomical snuffbox. The tendon end is frequently adherent to its sheath and to the surrounding structures, and may be encircled by new vascular connective tissue, depending somewhat upon the duration of the rupture prior to operative exploration. The proximal portion of the ruptured tendon usually retracts upward, so that its end is either at the upper edge of the dorsal radiocarpal ligament, or even more proximal to this. As much as five centimeters sometimes separate the two tendon ends. This proximal end is also bound down with adhesions, and the groove on the dorsum of the radius, through which it passes, becomes obliterated. The end of the distal tendon stump is usually somewhat swollen, bulbous, yellower than normal, and lacks the luster of a normal tendon. Sometimes this end may be ecchymosed and actually softer than the normal tendon. Microscopic examination of the excised degenerated end of these tendons shows hyaline degeneration of the tendon fibers; and there is often infiltration with lymphocytes, fibroblasts, and, occasionally, granulation tissue. One specimen, when stained with *Scharlach R*, showed the presence of fat between the tendon fibers.

LATENT PERIOD OF RUPTURE

The average period between fracture and the rupture of the extensor pollicis longus tendon is said by Kwedar and Mitchell to be six weeks; McMaster states that it usually occurs between the third week and the third month. In the five cases reported in this article, the earliest rupture occurred twenty days, and the latest six weeks, after fracture; the average latent period for the five cases was twenty-nine days.

INCIDENCE OF RUPTURE

The ratio of rupture of the tendon after fracture to the total number of Colles's fractures is said by Pörsch, Oppolzer, and Horwitz to be 1 to 270. On the Fracture Service of the Presbyterian Hospital, 1,341 Colles's fractures were treated between 1929 and 1943, inclusive. In five of these cases, there was subsequent rupture of the extensor pollicis longus tendon, giving a ratio of 1 to 268. The majority of ruptures have occurred in the left wrist. Kwedar and Mitchell, in reviewing the literature, found the complication more frequent in females (sixty per cent.). All five patients whose histories are reported in this article were females. The tendon rupture may be seen at practically any age, but is more common after thirty years. The youngest patient was reported by Lülsdorf, and was a girl of fourteen years.

In two of the five cases reported here (Case 3 and Case 4), the patients sought treatment late, that is, nineteen days and two months, respectively, after their falls. Neither patient suspected she had a fracture before coming to the Clinic. Since in neither case had the fracture been reduced or the wrist splinted, it is impossible to consider rough manipulation or faulty splints as a predisposing cause of the tendon rupture. In Case 3 the tendon ruptured almost under our own eyes, the day after the patient's first visit to the Clinic, while she was carrying out finger and thumb exercises.

FUNCTION

The extensor pollicis longus tendon has a dual function. This is poorly understood or completely ignored by the textbooks of anatomy. They point out that this tendon inserts on the dorsum of the base of the distal phalanx of the thumb, and that its action is to extend the distal phalanx upon the proximal phalanx at the interphalangeal joint. This

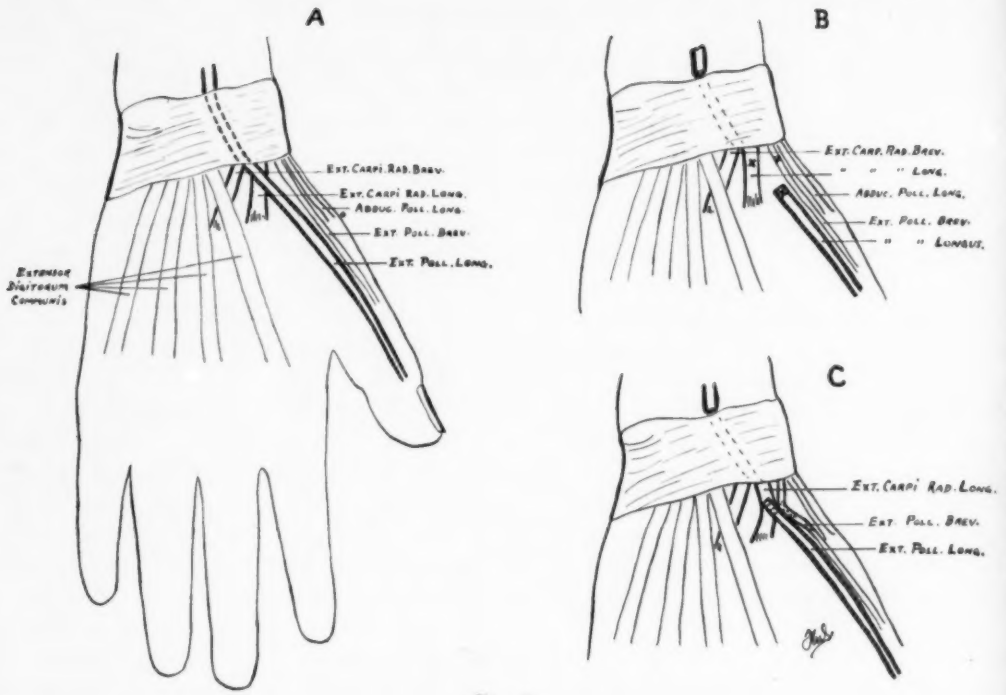

FIG. 6

A: Normal relations of tendons at dorsum of wrist and thumb.
B: Relation of tendons after rupture of extensor pollicis longus tendon.
C: Hook-up of extensor pollicis longus tendon to restore obliquity of its pull, as suggested by the author.

is only half of this tendon's function, and, in the writer's opinion, the less important half. In describing the deformity of the thumb with a ruptured extensor pollicis longus tendon, it was stated that the thumb drooped as a whole. This drooping of the thumb is due entirely to the loss of the *oblique* pull of the tendon. Neither the extensor pollicis brevis tendon nor the abductor pollicis longus tendon, nor both together, can overcome this droop when the extensor pollicis longus is ruptured. Any operative procedure designed to restore full function must therefore restore the obliquity of its pull (Fig. 6). If this very important half of its function is not restored, the patient will be able only to extend the distal phalanx but not to lift the thumb, and consequently will be handicapped in many activities.

OPERATIVE REPAIR

The ideal method of repair would be by resuture of the ruptured tendon ends directly, or by implantation of a free tendon graft between the ends. This would restore the normal continuity of the ruptured tendon, and replace it in its normal position. However ideal this would seem mechanically, it requires much freeing of adhesions; the resultant bleeding would give rise to more and denser adhesions during postoperative immobilization, which would "freeze" the tendon and make it non-functioning. In Case 1, although restoration of the obliquity of the pull of the extensor pollicis longus was accomplished by suturing the distal stump to the tendon of the extensor carpi radialis longus, the writer now considers this a mistake, because of the short excursion of the latter tendon due to the proximity to its insertion. If the distal end of the extensor pollicis longus is sutured to the extensor pollicis brevis, to the abductor pollicis longus, or to both, only active extension of the distal phalanx of the thumb will be restored, as mentioned heretofore. At the present time, following experiences with the first three cases, the writer feels that the most satisfactory hook-up to restore both functions is to suture the distal end of the extensor pollicis

TABLE II

REPAIR OF RUPTURED EXTENSOR POLLICIS LONGUS TENDON

Case No.	Tendons to which Distal Extensor Pollicis Longus Tendon Was Sutured	Restoration of Function of Thumb
1	Extensor carpi radialis longus	+
2	Extensor pollicis brevis	+++
3	Extensor pollicis brevis and abductor pollicis longus	++
4	Extensor carpi radialis longus and extensor pollicis brevis	++++
5	Extensor pollicis brevis and extensor carpi radialis longus	++

longus to the extensor carpi radialis longus by an end-to-side suture; following this, the tendon of the extensor pollicis brevis is drawn over to it and sutured additionally by a side-to-side suture. No. C silk is sufficiently large and strong, if three or four mattress-type sutures are used at each junction (Fig. 6). The thumb should be held in full extension and elevated dorsally while its long extensor tendon is being sutured to the extensor carpi radialis longus. This first hook-up gives the lift to the thumb, and the extensor pollicis brevis adds extension to the distal phalanx. Table II summarizes the method of repair in the five cases, and the results of the dorsal lift secured.

The writer has not used the method of repair described by Biesalski and Mayer, in which the tendon of the extensor indicis proprius, or half of it, is transplanted and sutured to the distal stump of the extensor pollicis longus. This method seems logical, but would appear to have the drawback of lack of obliquity of its groove in the dorsum of the radius. By making this tendon take over the oblique pull of the extensor pollicis longus, a tenosynovitis might conceivably result as it is pulled around a sharp corner. However, no one person has used enough of these various methods to be in a position to lay down positive rules as to the proper method of repair. The advantage of the method advocated by the writer is simplicity of technique without extensive additional dissection, and without the possibility of weakening the extension of the index finger.

It is important, when exploring and repairing the tendon, to isolate and protect the superficial branch of the radial nerve, since damage to this nerve may lead to distressing numbness of the dorsum of the thumb.

POSTOPERATIVE CARE

Following operative closure, the hand, wrist, and forearm should be immobilized in a volar molded plaster splint in slight cock-up position, with the thumb fully extended and elevated. The patient may leave the hospital on the third or fourth postoperative day. Skin sutures are removed after one week. The splint may be removed at the end of ten days, and the patient is encouraged to begin moving the thumb very gently in flexion and extension. He should then be advised to remove the splint three or four times daily for exercises and for hot soaks. Usually at the end of three weeks, or at most four weeks, it is possible to discard the splint completely. The exercises are then increased, and the patient is encouraged to begin mild active use of the thumb. By this method, the thumb is protected from sudden violent motions during the period of healing of the repaired tendon; yet, if gentle motion is started early, it should prevent the formation of dense adhesions which might later "freeze" the tendon motion.

FOLLOW-UP RESULTS

Unless operative repair of the ruptured extensor pollicis longus tendon is carried out, there can be no expectation of improvement in function of the thumb. It is gratifying to note that in all of the reported cases, after repair of the tendon, the patients showed im-

TABLE III

CLINICAL SUMMARY OF FIVE CASES OF RUPTURE OF EXTENSOR POLLICIS LONGUS TENDON

Case No.	Age	Sex	Occupation	Side	Date of Fracture	Time Intervals					Results
						Latent Period of Tendon Rupture	From Rupture to Operation	Period of Post-operative Splinting	Repair to Active Motion	Operation to Last Follow-up	
1	65	F	Housewife	L	Apr. 30, 1936	25 days	10 days	2 weeks	2 weeks	5 months	Fair to good
2	30	F	Cook	L	Jan. 18, 1938	6 weeks	51 days	3 weeks	3 weeks	17 months	Good to excellent
3	46	F	Housewife	R	Jan. 28, 1939	20 days	1 day	23 days	23 days	5 years, 9 months	Excellent
4	21	F	Waitress	L	Apr. 26, 1939	4½ weeks	7 weeks	4 weeks	8 days	5½ years	Excellent
5	55	F	Factory worker	L	July 10, 1943	27 days	17 days	22 days	22 days	13 months	Good
Average Time						29 days	17 days	3 weeks	3 weeks		

provement both in function and in use. The best follow-up results from a functional standpoint were found in those cases in which, in addition to restoration of the active extension of the distal phalanx, an attempt was made to restore the obliquity of pull of this tendon and thereby improve the patient's ability to elevate the thumb. All of the patients mentioned in this paper have been able to return to their previous occupations following operative repair of the tendon, with very little subjective handicap (Table III).

CONCLUSIONS

1. Late spontaneous rupture of the extensor pollicis longus tendon following Colles's fracture is a rare complication, and one that is not often recognized. This paper adds five cases to those previously reported in the literature.

2. The rupture is, in all probability, due to aseptic necrosis of the tendon, following injury to its blood supply.

3. The history and physical signs are very characteristic.

4. Return of function without operation cannot be expected. With operation, a good to excellent return of function may be expected.

5. Stress has been laid upon the dual function of the *oblique* pull of the extensor pollicis longus tendon, and a method of repair has been suggested to accomplish this functional restoration.

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ORTHOROENTGENOGRAPHY AS A METHOD OF MEASURING THE BONES OF THE LOWER EXTREMITIES

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Accurate measurement of the length of the lower extremities is often indicated. For many purposes clinical measurements suffice, but they are admittedly grossly inaccurate. The usual method of teleoroentgenography, although allowing more accurate records of comparative lengths, produces an increasing degree of magnification and distortion as the extremities grow (Fig. 1-A).

In a study of growth by the Harvard Infantile Paralysis Commission, it was found necessary to develop a method of measuring the lower extremities which would meet the following requirements:

1. Measurement of the bones should be sufficiently accurate to record the comparative true lengths at any one examination.

2. The precision of measurement should remain constant for varying bone lengths, in order to compute accurately the true increments of growth.

3. Sufficient detail should be delineated to allow the detection of abnormalities in the bones and visualization of the epiphyseal lines.

The method to be described has been designated "orthoroentgenography". It has met these requirements while in use over a period of four years, during which time over 2,200 recordings have been made.

METHOD

The method employs three separate exposures for the lower extremity (Fig. 1-B). The central ray is directed successively over each of the three joints, and the three exposures are processed on a continuous film,* fourteen inches in width and of any desired length up to forty-four inches. The technical factors may be varied between exposures, according to the thickness of the soft tissue over each part. A target-to-film distance of six feet is always used.

A tunnel for a long cassette (fourteen inches by forty-four inches) has been devised, into which have been incorporated two sliding metal shields (Fig. 2). Such a device allows an exposure to be made over any one third of the film, while the other two thirds are protected from exposure.

The patient is placed on the cassette holder in the supine position, with the hips level and the extremities parallel; straps are fastened over the lower thighs and over the ankles to hold the limbs in the proper position (Fig. 3).

Three exposures are made in sequence. In the first, the tube is centered over the hip joint with both shields in the distal position; in the second, the tube is over the knee joint with one shield in the proximal position and the other in the distal position; in the final exposure the tube is centered over the ankle joint, with both shields in the proximal position.

The centering of the tube in each exposure is checked by a long metal marker, placed horizontally at right angles to the side of the cassette. One end, pointing at the level of the joint to be exposed, extends over the cassette far enough to cast a shadow on the film; the other end indicates the position of the tube stand for the exposure. In this way,

* The film is purchased in rolls seventy-five feet long and stored in metal containers. Just before exposure, the film is cut to the length required for each orthoroentgenogram. The cost for each individual averages $2.10, if a roll of film is purchased and only the necessary length of film is used.

Fig. 1-B

Fig. 1-A

Schematic representation of the relative lengths of shadows of the same bones filmed with a one-exposure and with a three-exposure technique.

Fig. 1-A: Divergent rays produce magnification in teleoroentgenography.

Fig. 1-B: Perpendicular rays intersect the ends of the bones in orthoroentgenography, recording the true length.

Fig. 2

Fig. 2: Diagram of cassette tunnel used for orthoroentgenograms.

The frame of the tunnel is constructed of welded channel, one and one-half by three inches, which is milled to form suitable grooves in which the cassette may slide and the shields be shifted. On one side of the long dimension of the frame is a narrow slot, through which the handles of the shields protrude. The top is made of polished bakelite, one-eighth of an inch thick, and is fastened to the frame with screws. The shields are made of cold rolled steel and are mounted on tracks in order to be moved alternately into the central opening. Steel rods, one-half inch in diameter, are mounted on either side, one-quarter inch above the bakelite surface, to permit the attachment of restraining straps.

the exact level of focus is permanently recorded on the finished orthoroentgenogram (Fig. 4-B). The distance of six feet from tube to film decreases any slight inaccuracy occasioned by imperfect centering.

In teleoroentgenography the divergence of the rays from the tube produces considerable magnification, even when a distance of six feet from tube to film is used. The amount of magnification is variable, depending upon the length of the bone, the distance of the bone from the film, and the centering of the tube (Table I). Although teleoroentgenograms do not give the true lengths of bones, they do allow fairly accurate estimates of the relative lengths of the two extremities at a single examination. If they are used for serial measurements of growth, however, a variable distortion arises which makes them unsatisfactory, since the magnification becomes greater with the growth of the individual. This increased distortion is produced both by the increase in the bone-to-film distance, resulting from the thickening of the posterior structures, and by the increased length of the bones themselves, which places the bone ends nearer the periphery of the diverging roentgenographic beam.

FIG. 3

Patient in position for orthoroentgenogram. The extremities are steadied by restraining straps, and the cassette is being slid into the tunnel.

In part, the error of magnification in teleoroentgenographic mensuration can be corrected mathematically by triangulation. Difficulties in computation arise from the fact that the two ends of a given bone vary in height from the film. Furthermore, the computations are time-consuming and the results are inaccurate, since the distances of the bones from the film can only be estimated.

The accuracy of the measurements of teleoroentgenograms might be improved by the use of a radiopaque ruler, placed parallel to the bones and at an equal distance from the film, following the principle used in the Thoms method of roentgen pelvimetry. In practice, however, it was found impossible to place the ruler precisely enough to warrant its use. Teleoroentgenography, or one of its modifications, was considered not sufficiently accurate for our purposes.

Merrill described a method which allows more accurate measurement than does teleoroentgenography. He used three exposures on separate films, and measurements were made from a superimposed numbered metallic scale. This method does not allow visualization of the full length of the bones, no technique of checking the accuracy of focus was provided, and the focal distance used was only forty-two inches.

Consideration was given to the use of some adaptation of the slit scanogram.[3] It was decided, however, that an exposure of the necessary length and intensity would be unduly wearing on the roentgenographic tube, and the available equipment precluded any experimentation along these lines. Gill and Abbott have since described a modification of the slit-scanographic technique in the measurement of the bones of the lower extremities. They obtained films of good quality which recorded the exact length of the bones.

TABLE I

COMPARATIVE MEASUREMENTS OF THE LOWER EXTREMITIES IN TWENTY CASES BY ORTHOROENTGENOGRAPHY AND BY TELEOROENTGENOGRAPHY

Variations in the Measured Length of Bones as Obtained from Orthoroentgenograms with Those Obtained from Long Teleoroentgenograms (One Exposure of the Whole Lower Extremity on a Single Film) and from Short Teleoroentgenograms (Separate Films for the Femora and Tibiae)

FEMORA				TIBIAE			
Ortho. (*Cm.*)	Long Teleo. (*Cm.*)	Difference (*Cm.*)	Teleo. / Ortho.	Ortho. (*Cm.*)	Long Teleo. (*Cm.*)	Difference (*Cm.*)	Teleo. / Ortho.
30.0	31.1	1.1	1.037	20.4	21.0	0.6	1.029
32.4	33.6	1.2	1.037	22.7	23.4	0.7	1.031
34.2	35.5	1.3	1.038	24.0	24.7	0.7	1.029
36.7	38.2	1.5	1.041	26.6	27.3	0.7	1.026
38.4	39.7	1.3	1.034	28.2	29.0	0.8	1.028
40.0	41.5	1.5	1.038	30.5	31.4	0.9	1.030
42.2	43.8	1.6	1.038	32.3	33.2	0.9	1.028
44.7	46.6	1.9	1.042	34.9	35.9	1.0	1.029
46.5	49.3	2.8	1.060	35.6	36.7	1.1	1.031
45.5 *	49.2 *	3.7	1.081	37.0 *	38.5 *	1.5	1.040
Ortho. (*Cm.*)	Short Teleo. (*Cm.*)	Difference (*Cm.*)	Teleo. / Ortho.	Ortho. (*Cm.*)	Short Teleo. (*Cm.*)	Difference (*Cm.*)	Teleo. / Ortho.
29.4	30.4	1.0	1.034	20.9	21.7	0.8	1.038
32.9	34.3	1.4	1.042	23.4	24.3	0.9	1.038
34.0	35.5	1.5	1.044	25.0	26.0	1.0	1.040
36.8	38.4	1.6	1.043	27.5	28.6	1.1	1.040
38.3	40.2	1.9	1.050	28.7	29.9	1.2	1.042
40.3	42.2	1.9	1.047	30.0	31.4	1.4	1.047
42.2	44.3	2.1	1.050	33.0	34.5	1.5	1.045
43.9	46.2	2.3	1.052	34.4	35.9	1.5	1.044
46.7	49.3	2.6	1.056	37.7	39.3	1.6	1.042
45.5 *	48.2 *	2.7	1.059	37.0 *	38.6 *	1.6	1.043

* Measurements are from roentgenograms of skeletons. Focus on long teleoroentgenogram of skeleton was at the knee; compare magnification with other long teleoroentgenograms, where focus was over the femur.

ORTHOROENTGENOGRAMS

Orthoroentgenograms give a permanent, verifiable record of the lengths of the bones of the lower extremities. Because only perpendicular rays are directed at the ends of the long bones, magnification of length is eliminated, and visualization of each undistorted epiphyseal line is possible. The accuracy obtained with this method is such that increments of length can be reliably measured in growing children over an interval as short as three months.

The true length of each bone can be measured directly from orthoroentgenograms without computation; there is no significant magnification of length due to the divergence of the rays, because the focal spot is placed exactly over each joint.† Special high-speed roentgenographic equipment is not necessary for these films; the strain on the tube is no greater than it would be in filming separately a hip, a knee, and an ankle.

Comparison of the lengths of bones, using orthoroentgenograms and teleoroentgeno-

† Although orthoroentgenograms record the exact distance from one end of the bone to the other, slight shortening would occur if the bone were not parallel to the film. In the femur, for example, a minimal amount of shortening must occur, due to the oblique position of the bone. This could be corrected by elevating the knee and ankle to the same level as the head of the femur. The error involved is, however, so slight that such a procedure was thought undesirable, as it would be overbalanced by the loss of bone detail due to the increased distance of the object from the film.

FIG. 4-A

FIG. 4-B

Comparative roentgenograms of the same child, taken by two different methods.

Fig. 4-A: In the teleoroentgenogram, note the variability in visualization of the bones. The upper ends of the femora are poorly shown. The combined length of the bones in the right leg is 79.0 centimeters; in the left leg, 79.6 centimeters.

Fig. 4-B: In the orthoroentgenogram, note the greater evenness of visualization. The combined length of the bones in the right leg is 75.6 centimeters; in the left leg, 76.1 centimeters. The difference in extremity lengths, as measured by the two films, is 3.4 centimeters on the right and 3.5 centimeters on the left. This represents the magnification produced in the teleoroentgenogram.

The position of the metal marker can be seen opposite each joint on the right leg; it is much more easily visualized in the original film than in the photographic reproduction.

grams, has always revealed a considerable degree of magnification in the teleoroentgenogram (Table I). This occurs whether the teleoroentgenogram is made on a long film with a single exposure for the entire lower extremity, or on two short films with separate exposures for the femora and the tibiae. The magnification is greater with the longer bones, although it is modified by the relative thickness of the soft tissues, which in turn modifies the distance of the bones from the film.

Whereas the magnification of the femur in the long and the short teleoroentgenograms is essentially the same, the tibia shows somewhat less magnification in the long film. This arises from the fact that in the long teleoroentgenogram the tube is centered over the lower femur to provide better visual detail. The rays intersecting the two ends of the femur are thus similarly divergent in the two types of film. However, in the long film, since the tube is centered over the femur, the rays intersecting the upper end of the tibia tend to produce some foreshortening. This illustrates one of the difficulties in the use of teleoroentgenograms for serial study, since variation in the points of focus affects the length of the shadows obtained.

The measurements obtained from orthoroentgenograms show little deviation from the real length of bones. Orthoroentgenographic measurement of a dissected adult femur, 45.7 centimeters long, gave a length of 45.5 centimeters; that of an adult tibia, 37.0 centimeters long, was 37.0 centimeters by orthoroentgenogram. The lengths of these bones, as recorded on a long teleoroentgenogram centered at the knee, were 49.2 centimeters for the femur and 38.5 centimeters for the tibia; on short teleoroentgenograms they were 48.2 centimeters and 38.6 centimeters, respectively. In these exposures the bones were placed at a distance from the film comparable to that which would exist in a patient.

Since the whole of both lower extremities is presented on a single film in an orthoroentgenogram, details of the structure of the bone and any factors of deformity can readily be evaluated. The only loss of visualization is produced by the overlapping of shadows at the junction of the shields, but this point can be placed at the mid-shaft, where it is of little consequence. The amount of bone not visible on the film is that which represents the magnification produced in a teleoroentgenogram.

Some distortion in length can occur in the orthoroentgenogram, if the tube is not centered over the end of the bone. For this reason the exact points of focus are recorded on each film with a metal marker. If the focal spot should be significantly above or below the end of the bone, the film could be repeated. In practice this has seldom been necessary, and the marker serves primarily as a verification of technique.

Motion of the patient between exposures must not occur. This is controlled by placing the patient in a comfortable position, by strapping the legs, and by the vigilance of the technician. If the cooperation of the patient is secured, the factor of motion offers no more difficulty than in any other roentgenographic procedure.

If there is a marked discrepancy in the length of the two extremities, there will be a small amount of relative distortion in the measured length of the bone over which the tube is improperly centered. In such cases, the two extremities may be exposed separately.

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LIGAMENTS OF THE KNEE JOINT

The Relationship of the Ligament of Humphry to the Ligament of Wrisberg

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The ligament of Humphry, and its relation to Wrisberg's ligament of the knee joint, seems to have escaped the attention of many clinical surgeons and not a few anatomists. It seems worth while, therefore, to review briefly this anatomical structure.

George Murray Humphry described the ligament in 1858. He stated that the posterior aspect of the lateral meniscus is attached by fibers that pass in front of or behind the posterior cruciate ligament. Poirier and Charpy, in 1899, wrote that the attachment of the lateral meniscus to the medial condyle of the femur is constant and very strong; it has been considered a third cruciate ligament. At times it separates into two bundles, one of which passes in front of, and the other behind, the posterior cruciate ligament.

The standard textbooks of anatomy describe the ligament of Wrisberg and place it behind the posterior cruciate ligament, but do not mention the possibility of its being anterior to the posterior cruciate ligament. Grant states: "It is a matter of interest and significance that the posterior end of the lateral semilunar is attached to the femur by an oblique band that passes either in front of (lig. of Humphry) or behind (lig. of Wrisberg) the posterior cruciate ligament."

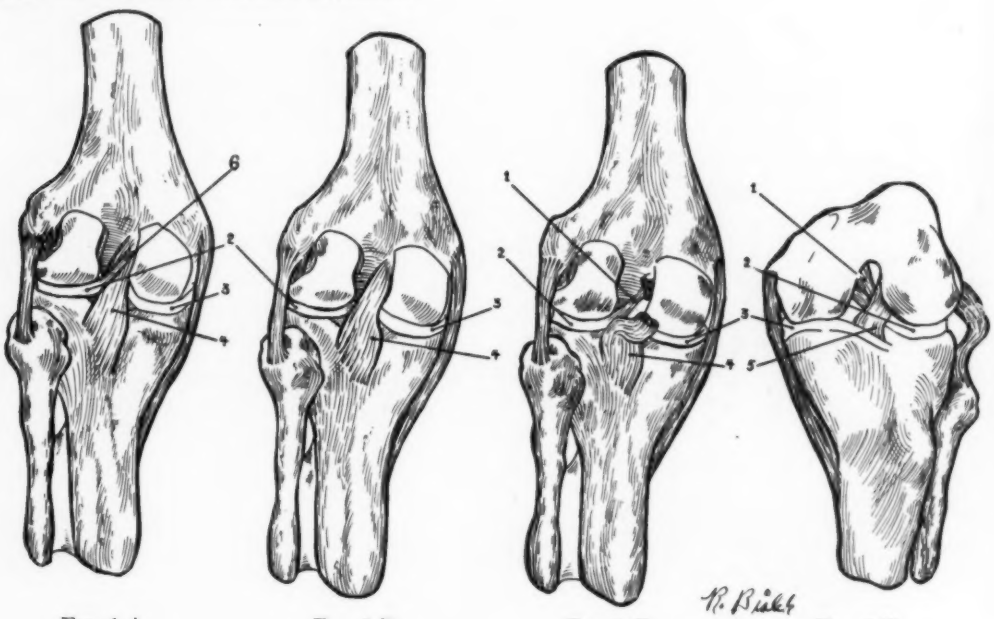

FIG. 1-A FIG. 1-B FIG. 1-C FIG. 1-D

1. Ligament of Humphry.
2. Lateral meniscus.
3. Medial meniscus.
4. Posterior cruciate ligament.
5. Anterior cruciate ligament.
6. Ligament of Wrisberg.

Fig. 1-A: The posterior aspect of a knee joint with its ligaments. The ligament of Wrisberg (*6*) is plainly seen and is typically illustrated.

Fig. 1-B: The ligament of Wrisberg is not present. The ligament of Humphry is present but does not show, since it is anterior to the posterior cruciate ligament (*4*) and is thus hidden from view.

Fig. 1-C: The same drawing as Fig. 1-B, but with the posterior cruciate ligament (*4*) cut and moved aside. The ligament of Humphry (*1*) is plainly seen, extending from the posterior aspect of the lateral meniscus (*2*) to the medial femoral condyle.

Fig. 1-D: A knee joint in a flexed position, viewed from the front. The synovial membrane has been removed from the cruciate ligaments. The ligament of Humphry (*1*) is plainly seen, lying on the anterior surface of the posterior cruciate ligament.

The authors found the ligament of Humphry only after very extensive dissection of the knee joint, and only then became cognizant of the writings of Humphry. The ligament of Wrisberg is behind the posterior cruciate ligament and extends from the posterior aspect of the lateral meniscus to the medial femoral condyle in an oblique upward and medial direction (Fig. 1-A). It may vary considerably in size. It is often rather intimately blended with the posterior cruciate ligament, but sometimes it is actually separated from the posterior cruciate ligament by several millimeters. Since it is the most posterior of the intra-articular ligaments, it is never covered with synovial membrane and accordingly is easily exposed to vision.

The ligament of Humphry is a fibrous fasciculus that originates from the posterior aspect of the lateral meniscus, extends obliquely medially and upward in front of the posterior cruciate ligament, and is inserted into the medial condyle of the femur (Fig. 1-C). It varies in size, as does the ligament of Wrisberg, but seems always to be in contact with the anterior aspect of the posterior cruciate ligament. It seems always to be covered with the synovial membrane that covers the cruciate ligaments, and is therefore obscured from view when the knee joint is exposed from the front (Fig. 1-D). It is hidden from view posteriorly by the posterior cruciate ligament (Fig. 1-B).

In a study of fifty anatomical specimens, a typical ligament of Wrisberg was found thirty times; a typical ligament of Humphry was found seventeen times. In three knee joints, there was a ligament both in front of and behind the posterior cruciate ligament. Two of these presented strong fibrous bands of a size equal to the usual ligaments of Wrisberg and Humphry. The third knee joint presented, in front of and behind the posterior cruciate ligament, a fasciculus considerably reduced in size. Examination of the knee joints of one cadaver revealed a typical ligament of Wrisberg in the right knee and a typical ligament of Humphry in the left knee. In this small series of fifty knee joints, a ligament extending from the posterior aspect of the lateral meniscus to the medial femoral condyle was invariably present.

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TREATMENT OF FRACTURE-DISLOCATION OF THE INTERPHALANGEAL JOINTS OF THE HAND

BY COLONEL ROBERT C. ROBERTSON, MAJOR JOHN J. CAWLEY, JR., AND MAJOR ARTHUR M. FARIS
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Fracture-dislocation of an interphalangeal joint in the hand results, in the absence of adequate treatment, in severe permanent disability. Reduction is difficult to maintain by conservative methods of splinting, because of pressure necrosis of the soft tissues. Treatment by open methods is unsatisfactory, because of the small size of the fragment and the proximity of the flexor and extensor tendons. Reduction and maintenance of the displacement by means of multiple skeletal traction has been employed by the authors, with excellent results. Previous reports of this method of treatment have not been found.

Fracture-dislocation of an interphalangeal joint of the hand is an uncommon injury. A total of seven cases were observed by the authors in a large general hospital over a period of one year. The usual causative mechanism is trauma to the end of the extended

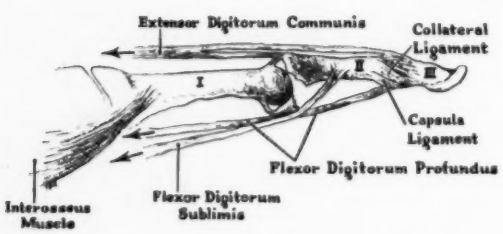

FIG. 1-A

Typical fracture-dislocation of an interphalangeal joint, showing displacements to be corrected.

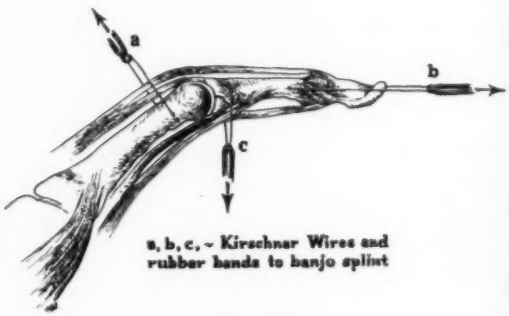

FIG. 1-B

Corrective forces applied by multiple traction.

finger. A small palmar fragment is retracted proximally by the capsular ligament, while dorsal dislocation is produced by the extensor digitorum tendon (Fig. 1). Capsular damage of varying degree is present. Deformity is immediate and marked. Accurate diagnosis can be made only by two-plane roentgenograms.

METHOD OF TREATMENT

The finger is prepared for surgery, and is covered with a sterile dressing. A plaster-of-Paris cast is applied from the proximal palmar crease high onto the forearm, and a wire banjo splint is incorporated in the desired position. Under general or local anaesthesia, a small Kirschner wire is inserted transversely through the neck of the phalanx, proximal to the dislocation; and another wire is placed transversely through the base of the phalanx, distal to the dislocation. A third wire is passed transversely through the neck of the middle phalanx, if the injury involves the proximal interphalangeal joint (Fig. 2-C). If the distal interphalangeal joint is involved, the third wire is passed transversely or vertically through the distal phalanx. In placing these wires, care must be taken to avoid the tendons and the joint capsule. A small temporary dressing is applied about each protruding wire. The wire is then cut and fashioned to form a traction bow. To each of the bows, a rubber band is attached and fixed to the banjo (Fig. 2-B). The involved joint is then flexed to from 20 to 30 degrees, and the desired traction is applied to each band at such an angle as to secure reduction of the displacement. Reduction is

TABLE I
REPORT OF CASES

TABLE I

REPORT OF CASES

Case	Diagnosis	Date and Manner of Injury	Reduction and Traction	Traction Removed	Result *
1	1. Fracture, simple, complete, chip type, anterior aspect, base of middle phalanx, left fourth finger. 2. Dislocation, simple, complete, posterior, proximal interphalangeal joint, left fourth finger.	Feb. 2, 1944, struck on end of extended fourth finger by baseball.	Feb. 4, 1944.	Mar. 5, 1944.	Good. Flexion range 175 to 90°. Motion painless, Mar. 15, 1944.
2	1. Fracture, simple, complete, chip type, anterior aspect, base of middle phalanx, right fifth finger. 2. Dislocation, simple, complete, posterior, proximal interphalangeal joint, right fifth finger.	Mar. 23, 1944, struck on end of extended fifth finger by baseball.	Mar. 24, 1944.	Apr. 21, 1944.	Good. Flexion range 180 to 100°. Motion painless, May 1, 1944.
3	1. Fracture, simple, complete, chip type, anterior aspect, base of middle phalanx, right second finger. 2. Dislocation, simple, complete, posterior, proximal interphalangeal joint, right second finger.	Apr. 12, 1944, struck on end of extended second finger by baseball.	Apr. 13, 1944.	May 7, 1944.	Good. Flexion range 180 to 100°. Motion painless, May 20, 1944.
4	1. Fracture, simple, complete, chip type, anterior aspect, base of middle phalanx, left fourth finger. 2. Dislocation, simple, complete, posterior, proximal interphalangeal joint, left fourth finger.	Apr. 26, 1944, struck on end of extended fourth finger by baseball.	Apr. 27, 1944.	May 18, 1944.	Good. Flexion range 180 to 100°. Motion painless, May 30, 1944.
5	1. Fracture, simple, complete, chip type, anterior aspect, base of middle phalanx, right third finger. 2. Dislocation, simple, complete, posterior, proximal interphalangeal joint, right third finger.	May 26, 1944, struck on end of extended third finger by baseball.	June 19, 1944.	July 17, 1944.	Good. Flexion range 175 to 110°. Motion painless, July 25, 1944.
6	1. Fracture, simple, complete, chip type, anterior aspect, base of distal phalanx, left thumb. 2. Dislocation, simple, incomplete, posterior, distal interphalangeal joint, left thumb.	May 21, 1944, struck on end of extended left thumb by baseball.	June 23, 1944.	July 14, 1944.	Good. Flexion range 180 to 110°. Motion painless, July 28, 1944.
7	1. Fracture, simple, complete, chip type, anterior aspect, base of middle phalanx, right fifth finger. 2. Dislocation, simple, complete, posterior, proximal interphalangeal joint, right fifth finger.	Sept. 7, 1944, struck on end of extended fifth finger by softball.	Sept. 8, 1944.	Sept. 30, 1944.	Good. Flexion range 175 to 110°. Motion painless, Oct. 5, 1944.

* Results here recorded were present upon return to duty. Rapid troop movements prevented recording final end results.

FIG. 2-A

Case No. 5, showing fracture-dislocation of proximal interphalangeal joint.

Fig. 2-A: Before reduction.

Fig. 2-B: Apparatus used in treatment.

Fig. 2-C: Reduction with traction applied.

Fig. 2-D: Final result.

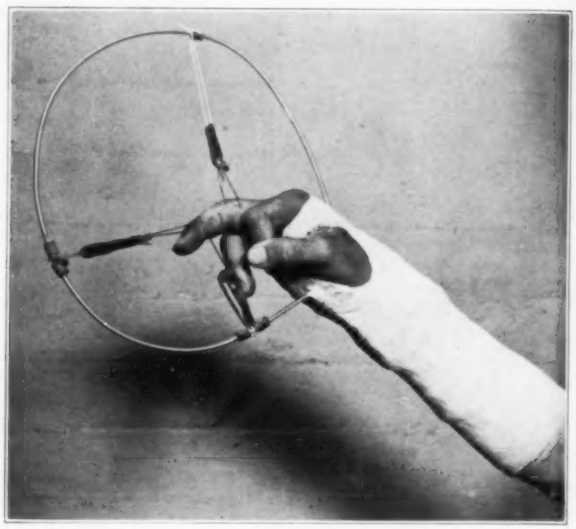

FIG. 2-B

FIG. 2-C

FIG. 2-D

checked by roentgenogram after a few hours, the necessary adjustments are made, and further roentgenographic observations are made, as indicated. Active motion of all joints of the uninjured fingers, and of the uninvolved joints of the injured finger, when possible, is instituted immediately and is continued throughout the treatment. Traction is removed after three or four weeks and physical therapy is given. The return of function is rapid (Table I).

In the seven cases treated by the authors, reduction of the dislocation was well maintained, and bony union of the fragments was secured. The shortest period of traction-fixation was twenty-one days, and the longest was thirty days. There were no operative infections. This method of treatment gives an excellent functional result.

THE POSITION OF THE EXTERNAL HIP JOINT IN THE ABOVE-THE-KNEE PROSTHESIS WITH PELVIC SUSPENSION

An Experimental Approach to the Problem *

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Limb makers, in designing above-the-knee prostheses, are becoming more and more convinced of the value of the pelvic type of suspension. The upper end of the prosthesis is articulated, through an external joint, with a rigid pelvic band. The limb moves freely in flexion and extension through the artificial and the intact hip joints, but abduction, adduction, and rotation are largely precluded by the arrangement. The axis around which flexion and extension occur extends from the external joint to the center of the hip joint.

The position of the joint, between pelvic band and prosthesis, should be such that the distal parts of the limb are moved forward in approximately a straight line, without appreciable abduction or adduction, when the thigh is flexed. Thomas has stated that a common error is to place the joint too far posteriorly, or over the greater trochanter of the femur. This results in an awkward gait, since the prosthesis moves outward, as well as forward, when the stump is flexed.

At the suggestion of Dr. Atha Thomas, the authors have devised an experimental method for determining the optimum position—so far as straight-forward flexion of the limb is concerned—of the external joint in the above-the-knee prosthesis with pelvic suspension.

MATERIALS AND METHODS

Three cadavera, whose hip joints were anatomically normal and freely movable in flexion, extension, abduction, adduction, and external and internal rotation, were utilized in this investigation. Each was placed in the supine position on a table, and firmly anchored in place by means of lag screws, which penetrated the table top from below and were screwed into the sacro-iliac joint.

An adjustable bracket (Figs. 6, 8, 10, and 12) was attached to the table, directly opposite the left hip joint of each cadaver. The right hip joint of the third cadaver was also studied. The upper end of the bracket contained a ball-and-socket joint, through the ball of which passed a snugly fitted brass rod. One end of the rod was sharpened and threaded for a short distance behind the point. The rod, when passed through the ball-and-socket joint and driven into the head of the femur, served as a fixed axis, around which passive flexion of the thigh could be carried out. The bracket was so constructed that the ball-and-socket joint could be moved anteriorly, posteriorly, rostrally, and caudally with relation to the hip joint; it was thus possible to simulate all possible positions of the external joint in the above-the-knee prosthesis with pelvic suspension and to determine which positions were most conducive to straight-forward flexion.

All soft tissues were left in place in the first cadaver studied. The sharpened end of the rod was driven through the soft tissues into the head of the femur (Figs. 4-A, 4-B, 5-A, and 5-B), where its position was checked, when considered necessary, by anteroposterior and lateral roentgenograms, taken with a portable roentgenographic unit. The capsule of the hip joint, and the neck and proximal part of the shaft of the femur, were exposed in each of the other two cadavera by removing the overlying tissues (Figs. 12 and 13).

Measurements were made to determine the relationship of the rod—at a point tan-

* Presented before the Rocky Mountain Section of the Society for Experimental Biology and Medicine, December 7, 1945.

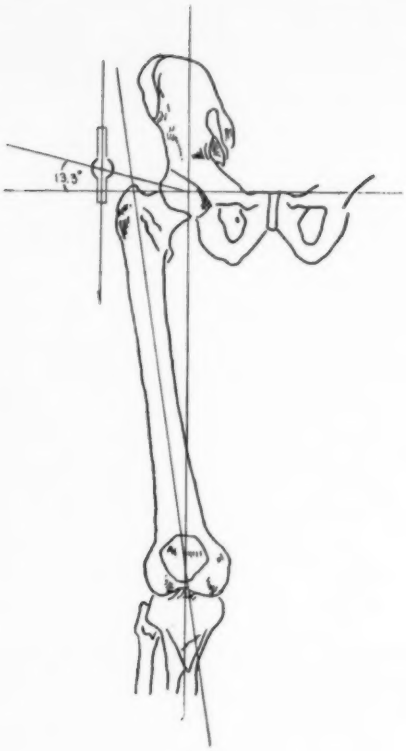

FIG. 1

The relation of the axis of rotation to the transverse acetabular plane in Position 1a. The relation of the axis to the greater trochanter is not accurately shown.

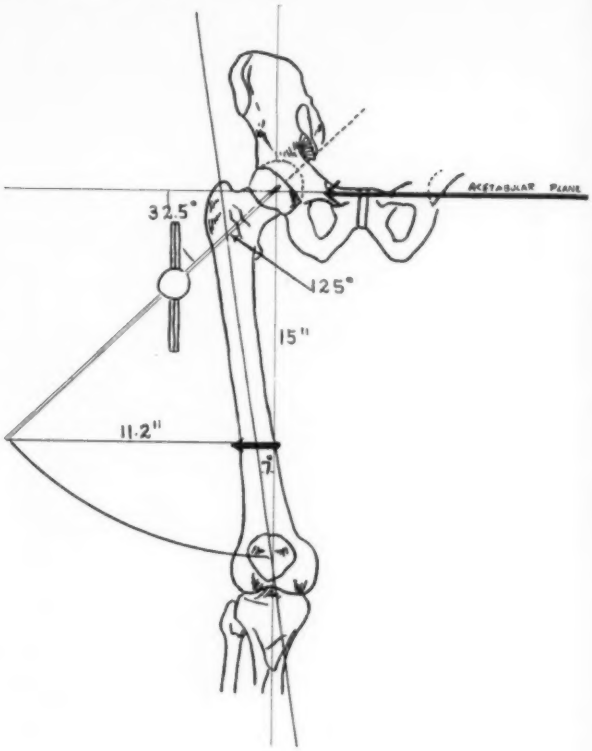

FIG. 3

The relation of the axis of rotation to the transverse acetabular plane in Position 3a. The drawing demonstrates that the axis of rotation does not shift during flexion to 54 degrees. The lateral displacement of the femur, if flexion were carried to 90 degrees around this axis, was calculated and found to be 11.2 inches. The lateral displacement which occurred at flexion of 54 degrees was six and one-quarter inches (Table I). The latter figure correlated in direct proportion with that calculated for theoretical flexion of 90 degrees, thus proving that the axis of rotation remains fixed in any desired position, so far as our experimental method is concerned.

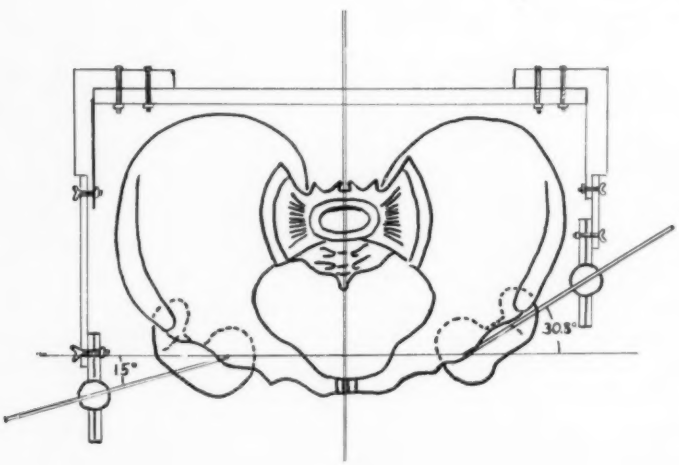

FIG. 2

The relation of the axes of rotation to the frontal plane of the pelvis in Position 1a (left) and Position 3a (right).

gent to the lateral surface of the thigh—to the frontal plane of the anterior superior iliac spines, to the transverse plane of the spines, and to the planes of the anterior and superior borders of the greater trochanter of the femur. The angles formed between the rod and the frontal and transverse planes of the anterior superior iliac spines were determined, as illustrated in Figures 1, 2, and 3. The degrees of rotation, abduction, and flexion of the thigh were also measured and recorded (Table I).

The deviation of the distal end of the femur (in abduction or adduction), with re-

TABLE I

RESULTS OF EXPERIMENTS

Position No.	Position of External Joint (Hip Joint of Prosthesis) Relative to Greater Trochanter * Ant. Border (*Inches*)	Greater Trochanter * Upper Border (*Inches*)	Frontal ** Plane (*Inches*)	Transverse ** Plane (*Inches*)	Angle † of Axis Rod with Frontal Plane (*Degrees*)	Transverse Plane (*Degrees*)	Starting Position of Thigh: Flexion (*Inches*)	Flexion (*Degrees*)	Abduction (*Inches*)	Abduction (*Degrees*)	External Rotation (*Degrees*)	Deviation of Femoral Condyles at 54° Flexion (*Inches*)	Relation of Position of Thigh at 54° Flexion to Anatomical Position (*Inches*)
1a	1	−¼	2½	2	15.0	13.3		0		0	47.0	Abd. ¾	
2a	−½	0	4	1¾	−19.3	19.0		0		0	47.0	Abd. 3¼	
3a	−¼	−1½	4½	4	−30.8	−32.5		0		0	67.2	Abd. 6¼	
4a	−¼	−1½	2	4	26.4	−32.5		0		0	11.0	Abd. ½	
5a	−¼	−1½	2¾	4	9.3	−32.5		0		0	27.0	Abd. 2¼	
6a	−¼	−1½	3	4	3.6	−32.5		0		0	32.8	Abd. 4½	
1b	1	¼	2½	2	−10.8	16.9		0	2½	8.0	65.0	Add. 4⅜	Add. 1⅞
2b	1½	−⅜	2¼	2	−5.1	16.9		0	3½	11.2	78.0	Add. 1¼	Abd. 2¼
3b	2	−½	1¼	2¾	17.8	−0.3		0	2½	8.0	59.0	Add. 3¾	Add. 1¼
4b	1⅜	0	2	2	0.7	16.9		23.0	4	12.8	45.0	Add. 3	Abd. 1
5b	0	−1	3⅛	3	−25.0	−6.0		23.0	4½	14.4	46.0	Abd. 1½	Abd. 6
1c	−½	−¼	3	2½	−27.9	5.0	3.0	10.5	4	14.0	50.0	Abd. 2¼	Abd. 6¼
2c	½	−¼	2	2½	−5.0	5.0	3.0	10.5	4	14.0	50.0	0	Abd. 4
3c	¾	0	1¾	2¼	0.7	10.7	3.0	10.5	4	14.0	50.0	Add. 1⅜	Abd. 2⅝
4c	1½	0	1	2¼	17.9	10.7	3.0	10.5	4	14.0	50.0	Add. 2⅛	Abd. 1⅞
5c	2¼	−¼	¼	2½	35.0	5.0	3.0	10.5	4	14.0	50.0	Add. 3⅛	Abd. ⅞
1d	¾	0	2¼	2¾	0	0	0		0		30.0	Add. 1¼	Add. 1¼
2d	¾	−⅛	2¼	2¾	0	0	0		2	7.0	30.0	Add. 2⅜	Add. ⅜
3d	¾	−¼	2¼	2¾	0	0	0		4	14.0	30.0	Add. 2⅜	Abd. 1⅝
4d	¾	−⅛	2¼	2¾	0	0	4.0	14.0	2	7.0	30.0	Add. ⅞	Abd. 1⅛
5d	¾	−¼	2¼	2¾	0	0	4.0	14.0	4	14.0	30.0	Add. ¾	Abd. 3¼
6d	⅞	−¼	2¼	2¾	0	0	4.0	14.0	4	14.0	45.0	Add. 1¾	Abd. 2¼
7d	¾	−¼	2½	2¾	−7.0	0	4.0	14.0	4	14.0	45.0	Add. ⅜	Abd. 3⅝

† Angles preceded by minus signs are posterior to frontal plane or inferior to transverse plane; others are anterior or superior.
* Minus sign signifies posterior or inferior; no prefix, anterior or superior.
** Through anterior superior iliac spines.

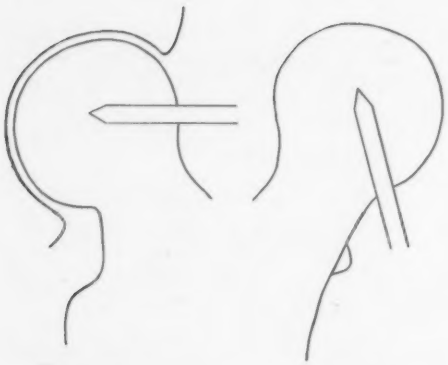

FIG. 4-A FIG. 4-B

Tracings of lateral and anteroposterior roentgenograms, showing the relation of the rod to the head of the femur in Position 1a.

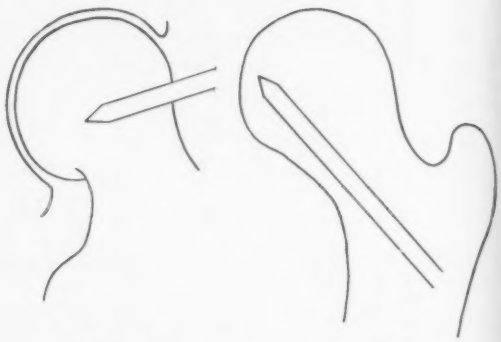

FIG. 5-A FIG. 5-B

Tracings of lateral and anteroposterior roentgenograms, showing the relation of the rod to the head of the femur in Position 2a. Because of the difficult conditions under which the roentgenograms were obtained, they could not be reproduced successfully.

lation to its starting and anatomical positions, was measured after flexion of the thigh to 54 degrees from each of twenty-three starting positions (Table I). Flexion was maintained, while measurements and photographs were taken, by means of a rod extending between the popliteal area of the thigh and the table; the rod was sharp at its point of contact with the table and did not influence the position of the limb as to lateral or medial deviation.

RESULTS

Six positions of the rod, as inserted through the ball-and-socket joint into the head of the femur, were studied in the first cadaver. A description of each position is presented in Table I; in none of the starting positions was there either flexion or abduction of the thigh. External rotation varied from 11 degrees, in Position 4a, to 67.2 degrees, in Position 3a.

The location of the ball-and-socket joint in Position 1a (Fig. 6) corresponded, as nearly as could be determined, to the location of the external joint in the illustrations of the pelvic-suspension type of prosthesis, published by Thomas. The point of the rod was well centered in the head of the femur, as shown by anteroposterior and lateral roentgenograms (Figs. 4-A and 4-B). External rotation, as measured at the condyles of the femur, amounted to 47 degrees. When the thigh was flexed 54 degrees, the medial condyle of the femur was found to have deviated laterally only three-quarters of an inch (Fig. 7).

The same degree of external rotation of the femur was present in the second position studied (Table I, Position 2a), but the rod was one-half inch posterior to the plane of the anterior border of the greater trochanter, and at the level of its upper border. This position represented an attempt to simulate placing the joint of the prosthesis over the greater trochanter, which has been done frequently, according to Thomas. The position of the pin in the head of the femur is shown in Figure 5. At the end point of flexion to 54 degrees around this axis, the medial condyle had moved laterally three and one-quarter inches from its original neutral position (Figs. 8 and 9).

The rod was next driven into the head of the femur through its neck. It entered the femur one-quarter inch posterior to the plane of the anterior border of the greater trochanter, and one and one-half inches inferior to its upper border (Fig. 10). This relationship of the rod to the femur was maintained in each of the next four experiments (Positions 3a, 4a, 5a, and 6a), while the degree of external rotation was varied from 67.2 degrees to 11 degrees.

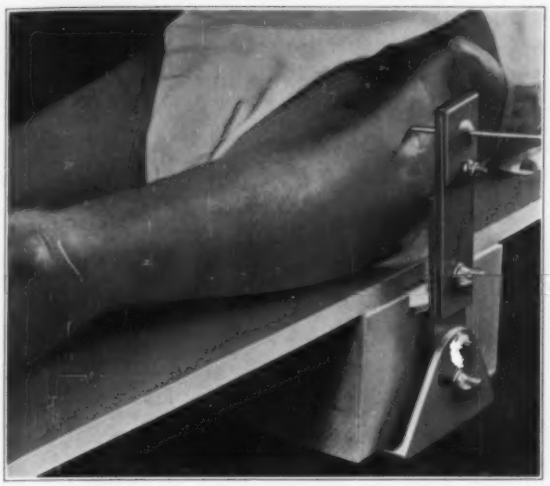

FIG. 6

Fig. 6. Position 1a prior to flexion.

FIG. 7

Fig. 7. The position of the left thigh when flexion of 54 degrees had been produced from Position 1a. The angle from which the photograph was taken accentuates the actual degree of abduction, which measured three-quarters of an inch. The external rotation of 47 degrees is indicated by the positions of the leg and foot.

The femur was externally rotated 67.2 degrees in Position 3a. At the end of 54 degrees of flexion, the medial condyle of the femur was abducted six and one-quarter inches from its original neutral position (Figs. 10 and 11). External rotation was reduced to 11 degrees in Position 4a, and abduction at 54 degrees of flexion amounted to only one-half inch. In Position 5a, external rotation measured 27 degrees; abduction at 54 degrees of flexion measured two and one-quarter inches. When external rotation was increased to 32.8 degrees (Position 6a), abduction in flexion increased to four and one-half inches.

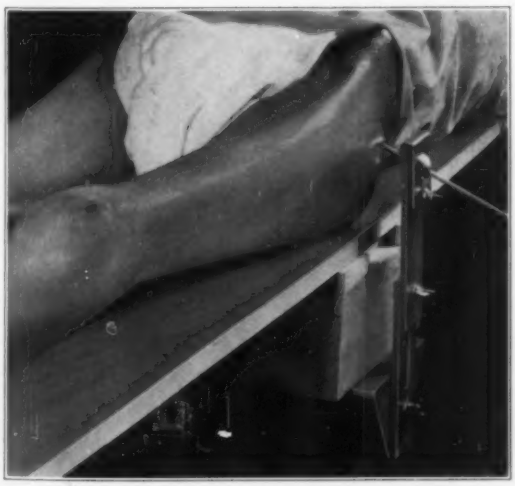

FIG. 8

Fig. 8. Position 2a prior to flexion.

FIG. 9

Fig. 9. Abduction of three and one-quarter inches, which occurred with flexion of 54 degrees from Position 2a.

In the second cadaver, flexion was first investigated from an originally abducted position of the thigh. Before driving the rod into the head of the femur in Position 1b, the thigh was abducted 8 degrees (two and one-half inches at the medial condyle), and externally rotated 65 degrees. The relationship of the rod to the frontal and transverse planes of the anterior superior iliac spines was the same as in Position 1a. Flexion of 54 degrees resulted in adduction from the starting position of four and three-eighths inches; thus the medial condyle was actually adducted one and seven-eighths inches beyond its anatomical position.

Beginning abduction was increased to 11.2 degrees (three and one-half inches at the medial condyle) in Position 2b, before the rod was inserted into the head of the femur. The position of the rod with relation to the frontal and transverse planes of the anterior superior iliac spines remained approximately the same as in Position 1b, but external rotation was increased to 78 degrees. Flexion of 54 degrees was accompanied by adduction from the starting position of only one and one-quarter inches. The thigh therefore remained in an abducted position (two and one-quarter inches) at the end point.

Abduction in Position 3b was 8 degrees, or the same as in Position 1b; external rotation was somewhat less (59 degrees). The external joint was moved anteriorly one and one-quarter inches, and inferiorly three-quarters of an inch. At the end point there had occurred adduction of four and three-quarters inches; this carried the medial condyle to a point one and one-quarter inches medial to its anatomical position.

In order to simulate the flexed position of the stump often seen after amputations of the upper thigh, the femur, in Position 4b, was flexed 23 degrees before the rod was driven into its head. The angle between the rod and the transverse plane of the iliac spines was the same as in Positions 1b and 2b; that between the rod and the frontal plane was practically zero (0.7 degree). External rotation amounted to 45 degrees, and abduction to 12.8 degrees (four inches). With flexion to 54 degrees, the abduction was reduced from four inches to one inch.

When the ball-and-socket joint was moved posteriorly and inferiorly, so that the rod was in the plane of the anterior border of the greater trochanter and one inch below the

FIG. 10

Position 3a prior to flexion. The inferior and posterior angles between the rod and the transverse and frontal planes of the pelvis are shown.

FIG. 11

Fig. 11: Abduction of six and one-quarter inches, as it occurred in flexion from Position 3a.

plane of its superior border (Position 5b), with abduction, external rotation, and flexion approximately the same as in Position 4b, flexion of 54 degrees resulted in exaggeration of the original abduction (from four and one-half to six inches).

In the investigation of the left hip of the third cadaver, it was felt that an attempt should be made to eliminate some of the numerous variables allowed in the previous experiments. Flexion, abduction, and external rotation of the thigh, in each starting position, were therefore kept constant at 10.5 degrees, 14 degrees, and 50 degrees, respectively; the relation of the rod to the transverse plane was varied only slightly. Thus the only actual variable was the angle between the rod and the frontal plane; this varied from a posterior angle of 27.9 degrees in Position 1c to an anterior angle of 35 degrees in Position 5c. In Position 1c, the original abduction of four inches was increased to six and one-quarter inches. When the posterior angle between the rod and the frontal plane was reduced to 5 degrees (Position 2c), the thigh moved straight forward; abduction at the start and at the end point (54 degrees of flexion) was four inches, or 14 degrees.

When the posterior angle was changed to an anterior angle, and then increased in size (Positions 3c, 4c, and 5c), adduction occurred in increasing amounts when the thigh was flexed. The adduction ranged from one and three-eighths inches, with an anterior angle of 0.7 degree, to three and one-eighth inches when the angle was increased to 35 degrees.

In the final experiment, utilizing the right hip joint of the third cadaver, the rod was kept parallel to the transverse and frontal planes of the anterior superior iliac spines throughout the first six positions (Positions 1d through 6d), while various combinations of external rotation, abduction, and flexion of the thigh were investigated.

When the thigh was externally rotated 30 degrees, without accompanying abduction or flexion, adduction of one and one-quarter inches occurred when it was flexed through the usual range of 54 degrees. The adduction was increased to two and three-eighths inches, when external rotation of 30 degrees at the start was accompanied by abduction of either 7 degrees or 14 degrees (Positions 2d and 3d).

Flexion of 14 degrees, combined with external rotation of 30 degrees and abduction of 7 degrees—simulating the position of the amputation stump—resulted in adduction of

FIG. 12

Position 4b prior to flexion to 54 degrees. The thigh was flexed and abducted before the rod was driven into the head of the femur.

FIG. 13

Fig. 13: Flexion to 54 degrees from Position 4b. Abduction was reduced from four inches, at the start, to one inch, at the end point.

only seven-eighths of an inch (Position 4d). The amount of adduction was practically unchanged when starting abduction was increased to 14 degrees, without changing flexion and external rotation (5d); this was consistent with the results in Positions 2d and 3d, where doubling the amount of abduction, without other changes, failed to alter the amount of deviation of the thigh at flexion of 54 degrees.

Flexion and abduction were the same in Position 6d as in Position 5d, but external rotation was increased from 30 degrees to 45 degrees; adduction at 54 degrees of flexion increased from three-quarters of an inch to one and three-quarters inches, as compared with the former position.

The relationship of the rod to the frontal plane was altered in Position 7d, while flexion, abduction, and external rotation of the limb were the same as in Position 6d; the parallel relationship between the rod and the transverse plane was maintained. A posterior angle of only 7 degrees between the frontal plane and the rod was sufficient to reduce adduction from one and three-quarters inches (Position 6d) to only three-eighths of an inch.

DISCUSSION

It is obviously impossible to draw definite conclusions as to the optimum position of the external joint, with reference to the trochanter and the various planes of the pelvis, which will be applicable to the fitting of above-the-knee prostheses to any and all amputation stumps. Our studies indicate that each of the innumerable combinations of flexion, abduction, and external rotation which are likely to exist in such stumps, and to which the sockets of the prostheses must be accommodated, will probably necessitate adjustments, of greater or lesser degree, in the location of the joint. The results of the present investigation appear to support the thesis that the joint should be placed considerably anterior to the greater trochanter, as stated by Thomas.

Regarding the position of the stump following thigh amputations, Langdale-Kelham stated that one could expect to find "any variation from a long femur stump with little flexion and no abduction, to a short femur stump markedly flexed 40 degrees or more, markedly abducted, and externally rotated". The muscular forces responsible for such postural deviations of the stump are not easily accounted for.

Steindler, in analyzing the dynamics of the muscles concerned with movements of the hip joint, found that flexion and abduction of the hip nullified the external rotary action of the posterior fibers of the gluteus medius, and that almost all the fibers of the gluteus minimus rotate inward in all positions of the hip joint. He considered the rotary power of the tensor fasciae latae, and that of the hamstring muscles, to be negligible. Both piriformis and obturator internis lose some of their external rotary power when the hip is flexed, according to Steindler, and the adductor magnus is a very weak internal rotator of the hip. The gracilis was considered to be an internal rotator of the "leg" in most positions. This analysis by Steindler does not furnish an anatomicophysiological basis for the marked external rotation observed in femoral stumps.

The abduction described by Langdale-Kelham as existing in short femoral stumps is, no doubt, explained by the loss of action of the adductor longus and adductor magnus. Flexion (and possibly some external rotation) is produced by the relatively unopposed action of the iliopsoas. The lack of opposition is mainly due to the loss of the normal extensor effects of the hamstring muscles. The marked decrease in weight of the stump, as compared with that of the normal extremity, is no doubt a contributing factor to the overactivity of the iliopsoas. The weight of the artificial limb should correct both flexion and abduction of the stump, to some extent.

Regardless of inability to explain the postural deviations which are seen in the stump following thigh amputations, they must be considered in determining the most favorable position of the external joint. Positions 1c, 2c, and 3c indicate that placing the external

joint one-half inch anterior to the greater trochanter (Position 2c) results in straight-forward flexion, as compared with flexion complicated by considerable abduction when the external joint is placed over the trochanter (1c), and by adduction when it is placed three-quarters of an inch anterior to the trochanter (3c).

Thomas's opinion, that good function in artificial limbs is not promoted by placing the external joint over the greater trochanter, seems justified in the light of the results obtained in these experiments when the external joint was placed in, or posterior to, the plane of the anterior border of the trochanter. Positions 2a, 3a, 4a, 5a, 5b, and 1c are illustrative of the type of flexion that may be expected from such a posterior placement of the joint. Abduction occurred in flexion from all of these positions, in spite of considerable variation in degrees of external rotation, abduction, and flexion at the start of the respective experiments. It is interesting that the amount of abduction was very slight (one-half inch) in Position 4a, in which external rotation was only 11 degrees; this indicates that the joint might be favorably placed over the greater trochanter, if a stump with this slight degree of external rotation should be found.

The external joint may also be placed too far anteriorly, as illustrated by Positions 3c, 4c, and 5c. Flexion, abduction, and external rotation of the thigh were kept constant in these three experiments, while the external joint was in planes three-quarters of an inch, one and one-half inches, and two and one-quarter inches anterior to the anterior border of the trochanter. With each increase in the distance between the axis of rotation and the trochanter, the adduction accompanying flexion of 54 degrees increased (one and three-eighths inches, two and one-eighth inches, and three and one-eighth inches, respectively).

Our most satisfactory results, from the standpoint of straight-forward flexion, were obtained from Positions 1a, 2c, and 7d. In the first of these, with the thigh in 47 degrees of external rotation, the rod was so placed that it made an angle of 15 degrees with the frontal plane of the anterior superior iliac spines, and an angle of 13.3 degrees with the transverse plane. It was one inch anterior to the anterior border of the greater trochanter, or approximately one and three-quarters inches anterior to its lateral mid-line.

In Position 2c, external rotation amounted to 50 degrees, and the thigh was abducted 14 degrees and flexed 10.5 degrees. There was a posterior angle of 5 degrees between the rod and the frontal plane, and the angle between the rod and the transverse plane was also 5 degrees. The distance from the middle of the trochanter to the rod was one and one-quarter inches.

External rotation in Position 7d amounted to 45 degrees, and flexion and abduction to 14 degrees each. The posterior angle between the rod and the frontal plane measured 7 degrees, and the rod was parallel to the transverse plane. The distance anterior to the anterior border of the trochanter was three-quarters of an inch; it was therefore one and one-half inches from the middle of the trochanter to the rod.

In the optimum positions of the external joint, as determined by our method of investigation, the distance anterior to the middle of the trochanter varied from one and one-quarter to one and three-quarters inches. In all of these favorable positions, the rod passed one-quarter inch inferior to the plane of the superior border of the trochanter. The angles between the axis rotation and the frontal and transverse planes of the anterior superior iliac spines did not exceed 15 degrees, and they tended to approach zero.

SUMMARY

Three human cadavera were utilized for the study of the effects of varying axes of rotation upon flexion of the thigh. The investigation was carried out in an attempt to determine the optimum functional position of the external hip joint in the above-the-knee prosthesis with pelvic suspension. Variations in the angles formed between the axes of rotation and the frontal and transverse planes of the anterior superior iliac spines were fa-

cilitated by an adjustable ball-and-socket joint; this was placed opposite the hip joint of the cadaver, and a rod was passed through it into the center of the head of the femur.

Flexion to 54 degrees was carried out from starting positions—characterized by various combinations of flexion, abduction, and external rotation of the thigh—which simulated the postural deviations observed clinically in amputation stumps.

The results indicate that, for straight-forward flexion to occur, the external joint should be placed from one and one-quarter to one and three-quarters inches anterior to the middle of the greater trochanter.

An axis which passed through the greater trochanter was conducive to considerable abduction, as the thigh was moved forward in flexion. Conversely, when the external joint was placed too far anteriorly, adduction was associated with flexion.

Considerable adjustment in the position of the external joint, within rather narrow limits, is necessary to compensate for varying degrees of flexion, abduction, and external rotation of the thigh.

NOTE: The authors wish to express their sincere appreciation to Dr. Atha Thomas for suggesting this investigation, and for constructive criticism of the work as it was carried out. Mr. Chester C. Haddan, President of the Association of Limb Manufacturers of America, has also given helpful suggestions and criticism. Thanks are due Mr. Glenn Mills for the excellent photographs, illustrating the methods and results of the experimental procedures. Miss Helen Veltrie of the Department of Roentgenology, University of Colorado Medical School, and Dr. Joseph McGill, were most cooperative in preparing the roentgenograms. The retouching of the illustrations was made possible by a grant from the Council on Research, University of Colorado Graduate School.

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MUTATIONAL DYSOSTOSIS (CLEIDOCRANIAL DYSOSTOSIS)

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Mutational dysostosis is a condition, frequently transmitted by parents to offspring, which is characterized by multiple, variable developmental skeletal anomalies. The more prominent and frequent of these anomalies are aplasia of the clavicles, delay in closure of fontanelles and cranial sutures, brachycephalia, prognathism, irregularities in dentition, and structural abnormalities in the skull bones, vertebrae, sacrum, pelvis, femora, scapulae, metacarpals, metatarsals, and phalanges.

Although Morand is usually credited with the earliest description of the disease, the case cited by him in 1766 was, according to Fitchet, definitely not one of mutational dysostosis. Terry states that, in 1760, Meckel reported an infant born without clavicles. In 1765, Martin reported the case of a man, thirty years old, one of whose clavicles was deficient posteriorly; the man's father, grandfather, and one uncle had abnormally mobile shoulders, and presumably abnormal clavicles.

The first authentic case to be reported in the English literature appears in the 1870 edition of the Descriptive Catalogue of the Warren Anatomical Museum of Harvard University as a contribution of Dr. Ephraim Cutter of Woburn, Massachusetts. The case was that of an eleven-year-old girl, who died of acute disease and whose imperfectly developed clavicle was presented to the Museum in 1868 with the notation that the other clavicle was similarly affected. The clavicle was one and three-quarters inches in length and about one-third of an inch in width, and was flattened and moderately curved. There was the usual attachment to the sternum but none to the scapula. The father of the child, who was exhibited to the Society for Medical Improvement by Dr. Cutter, had defects in both clavicles, but the outer half of each bone was indistinctly felt in connection with the scapula. The father stated that two of his brothers had the same malformation, and he thought that his father, from the slope of his shoulders, may have had the same defect. The girl had seven brothers and one sister; all of the boys had the malformation on one or both sides.

The first detailed description of the disease as a pathological entity was made by Marie and Sainton, who reported four cases, occurring in a mother and daughter in one family and in a father and son in another family. Marie and Sainton named the disease "*la dysostose cléido-cranienne héréditaire*", and stated that the cardinal features of the syndrome were: (1) a varying degree of aplasia of the clavicles; (2) overdevelopment of the transverse diameter of the cranium coincident with delay in ossification of the fontanelles; and (3) hereditary transmission.

The term "cleidocranial dysostosis" was applied to this affection by all writers until 1936, when Rhinehart called attention to its mutational character and to the variety and inconstancy of findings, and proposed the name "mutational dysostosis" as more rational and descriptive.

In 1929, Fitchet made an exhaustive survey of available literature on the subject, and abstracted all cases reported prior to that time. In this survey, 151 cases were collected, of which eighty-eight were familial, occurring in twenty-four different families, and sixty-three were either isolated or were without history of relationship to other persons having the disease.

In 1937, Engel collected a total of 228 cases reported in the literature, of which 106 were familial, occurring in twenty-five families, and 122 were sporadic.

The author has made a survey of all case reports and articles on mutational or cleidocranial dysostosis published from January 1929 through March 1944, as reported in the Quarterly Cumulative Index Medicus. These articles are listed in the bibliography. Six

additional cases are reported here. As a result of this survey, 172 cases have been added to those reported by Fitchet, of which 110 were familial, occurring in twenty-eight different families, and sixty-two were sporadic or without family history of the disease. Seventy-one were males, seventy-nine were females, and the sex of the remaining twenty-two was not reported. The surveys of Fitchet and the author give a total of 323 reported cases, of which 198 were familial, occurring in fifty-two families, and 125 were sporadic or isolated. Of these, approximately half were males.

The apparent rarity of the condition is indicated by the scarcity of published reports and anatomical specimens. Kinsella stated that in the museums of the world there were only nine skulls and two complete skeletons showing the condition; five of the skulls and both skeletons were in the Institute of Pathological Anatomy of the University of Vienna.

The geographic distribution has been interesting. Cases have been reported from every continent; the central European countries, England, and the United States have contributed the largest numbers.

While the majority of the cases cited have been of the familial type, examples of apparently sporadic occurrence are not at all uncommon. In many instances the histories

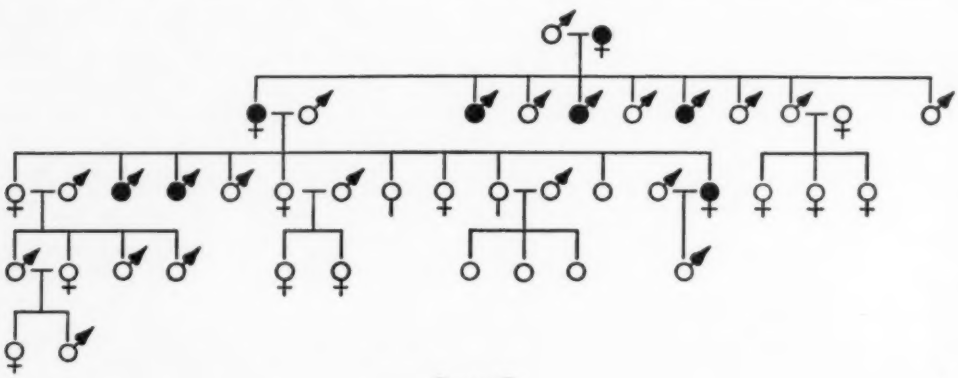

CHART I

Family reported by Carrière, Huriez, and Décamps.

have not been sufficiently detailed to rule out the occurrence of anomalies in other members of the families, and the relatives of many of these patients have not been examined carefully for signs of the disease.

In those cases showing a hereditary background, transmission has been by both male and female members of the family to a nearly equal degree. In the entire series of cases, the disease was known to have been transmitted by thirty males and thirty-two females. In many instances, the disease has appeared in two successive generations and has been lost in the following generation. In eight families, the disease appeared in three successive generations; in four families, it appeared in four successive generations; in one family, it appeared in five successive generations. No authentic instance could be found where the disease appeared in one generation, skipped one or more generations, and then reappeared in a subsequent generation. In the family studied by Langmead and by Carpenter, as reported by Fitchet, two affected children were born to parents who were said to have been normal; the parents were not examined, and discrepancies in the accounts of the family by the two authors throw discredit upon the accuracy of the study.

Examples are numerous of families in which the disease disappeared, not to reappear in subsequent generations. In the family reported by Carrière, Huriez, and Décamps, the disease appeared in eight individuals in three successive generations; in the two subsequent generations, no cases were present in eleven individuals (Chart I). In the family reported by La Chapelle, the disease appeared in at least eight members of three generations (Chart II). A normal woman of the second generation (whose mother and five of

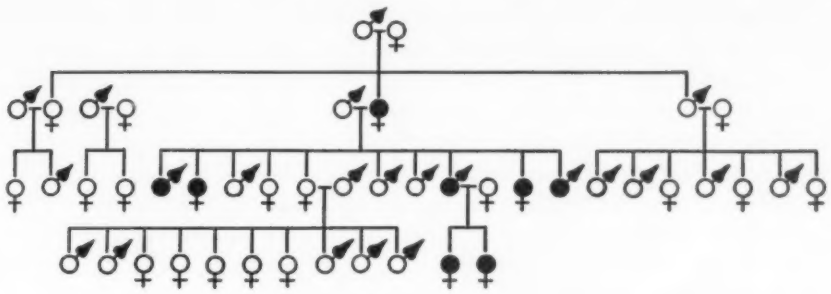

CHART II
Family reported by La Chapelle.

whose brothers and sisters had the disease) bore ten normal children. In the family reported by Burkens, La Chapelle, and Groen, the disease appeared in four generations; in the third generation, five out of thirteen individuals showed evidence of the disease; in the fourth generation, only one out of twenty-two individuals was affected (Chart III).

In families in which the disease appeared in several generations, it was transmitted to 134 individuals and not transmitted to seventy individuals. Examples are common in which four out of six, or seven out of eight children showed signs of the disease.

The etiology of the disease is unknown, but it is unquestionably associated with a defect in the parental germ plasm, as first suggested by Hultkrantz. Strauch believes that an endogenic cause operates, probably in the parental germ plasm, with defects of certain

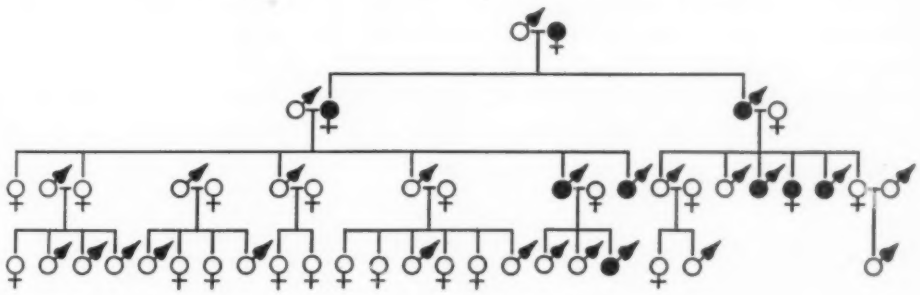

CHART III
Family reported by Burkens, La Chapelle, and Groen.

elementary building units of the chromosomes which carry the hereditary potentialities,—that is, there is a faulty *Anlage* in the system of membranous bones, the skull bones and clavicles, which is also present occasionally in the bones of chondral origin.

Another theory was advanced by Jansen, who suggested that the defects might be produced (during the eighth week of gestation) through compression of various parts of the growing foetus by a small amniotic sac. Jansen's theory fails to explain the pathogenesis of many of the conditions common to this disease,—notably the appearance of supernumerary digits in hands and feet, extra epiphyses, supernumerary teeth and vertebrae, delayed secondary dentition, and thickening of flat bones.

Greig, Fitzwilliams, and others have commented on the fact that most of the defects have been in bones formed in membrane. However, as Fitzwilliams and others have pointed out, there are many authentic examples of defects of bones or portions of bones not formed in membrane.

In his monograph on the development of the clavicle, Fawcett states that the earliest recognizable step in this process is noted in the embryo of eleven millimeters when a condensed, curved rod of connective tissue appears beneath the acromion process and the

first rib. Within this connective tissue is laid down an inner and an outer mass of precartilage; the former lies above and anterior to the latter and they are separated from one another by connective tissue. At seventeen millimeters, ossification begins in the center of each precartilaginous mass. At eighteen to nineteen millimeters, fusion occurs between the opposing ends of the two masses of precartilage, and a third center of ossification appears in the precartilaginous bridge. At twenty-seven millimeters, cartilage cells appear in the outer segment and the subsequent development of bone in this area occurs at the expense of the cartilage. Therefore, the clavicle develops in three segments,—outer, middle, and inner. In the outer and inner segments, bone is formed partially in membrane and partially in cartilage; in the middle segment, bone is formed wholly in membrane. Although knowledge of this process aids in the understanding of the embryological basis for the variations noted in the clavicular defects, it does not explain the failures of development and fusion.

Various theories have been advanced to explain the dental defects. Stocks, as quoted by Rushton, suggests that the abnormalities arise from restriction of the erupting area by the stunting of the jaws; he fails to explain the presence of supernumerary premolars and the absence of some of the molars. Fröhlich believes that all of the defects are part of the syndrome, and therefore are referable to deficiencies in the parental germ plasm.

Rushton cites Grüneberg's observations on grey-lethal mutation in the mouse, which is characterized by lack of all secondary bone absorption processes in the skeleton: The bone substance laid down in development is preserved in its entirety. The growth of the teeth is limited by the width and size of the sockets when the teeth are enclosed in them. The teeth assume peculiar shapes; some are narrow and others are compressed from above downward. Grüneberg states that the former concept of *stimulus* (pressure) leading directly to *response* (absorption) has to be revised to the concept of *stimulus* (pressure) plus an *hereditary basis for response* leading to *response* (absorption). Rushton, in commenting on Grüneberg's observations, suggests that the appearance and behavior of the teeth in mutational dysostosis may be due to a defect in the bone-absorption mechanism of the jaws.

Durante and Porak suggest that the disease may be a variant of osteogenesis imperfecta.

Rubens and several other writers report isolated cases of cleidocranial dysostosis which also showed abnormalities characteristic of craniofacial dysostosis with ocular hypertelorism (Crouzon's disease). The typical features of hypertelorism, as noted by Rubens, are a wide separation of the orbits, a brachycephalic skull with small face and large cranium, flattening of the occiput, and bulging of the temporal regions. The nasal bridge is broad and the tip of the nose is retroussé. The eyes may show an external strabismus. Mental deficiency occurs in the more severe cases.

Tuberculosis, syphilis, other infections and intoxications, consanguinity, and rickets seem to play no part in the etiology.

CHARACTERISTICS OF THE DISEASE

Mutational dysostosis is characterized by multiple defects in development and structure; these are almost wholly confined to the skeleton, except as certain skeletal abnormalities affect muscles and other organs. Most of the defects are present at birth, but many of them, especially the cranial and dental anomalies, become manifest as the child grows and develops. Variations from the typical abnormalities are common, and no one finding is characteristic of all cases.

Skull

The skull is brachycephalic, with a cephalic index of more than 80 degrees. The biparietal diameter is increased and the fronto-occipital diameter is decreased. There is

usually marked prominence of the frontal, parietal, and occipital bosses with depression of the sagittal suture, thus giving a "hot cross bun" effect, or natiform skull. The metopic suture, which in the foetus separates the two lateral halves of the frontal bone, persists into late childhood and frequently never fuses. There is delayed and often incomplete closure of the fontanelles, with persistence of large, irregular defects in the anterior, posterior, mastoid, and sphenoid fontanelles. Sometimes the fontanelles develop heavy fascial or thin bony coverings so that pulsation of the brain cannot be felt, but there is seldom complete bony closure with tables of normal thickness. Most of the suture lines are wide, depressed, and tortuous, and include many wormian bones derived from accessory centers of ossification. Variations in the supra-orbital ridges are common; although the ridges are usually overdeveloped and prominent, defects are occasionally seen.

The base of the skull is usually kyphotic. The sphenoid bone is underdeveloped, narrow, and short. The foramen magnum is large and faces forward and downward, so that a line drawn through the sagittal plane, when continued anteriorly, passes through the nasion or glabella. Occasionally, defects are noted in the posterior wall of the foramen magnum.

The bones of the face are generally underdeveloped, small, and asymmetrical. The superior maxillae and small facial bones show the greatest number of abnormalities. The maxillae are micrognathous and irregular in outline and structure with small, depressed frontal processes; the palate is highly arched, narrow, and occasionally cleft. The nasal, lacrimal, and malar bones are partially or wholly deficient, and gaps may be present between the zygomatic processes of the temporal bones and the corresponding processes of the superior maxillae. The mandible, on the other hand, is large, long, and prognathous, with obtuse angles. The alveolar process is broad. When the mouth is closed, the occlusal surface of the mandible is well forward of the corresponding surfaces of the maxillae. The mental suture is often wide, and the genial tubercles are often so much enlarged that they project backward like bony spines. The paranasal sinuses and mastoid cells are usually small; the latter may be absent or sclerosed. Occasionally the frontal sinuses are disproportionately large.

Teeth

Dental abnormalities are common, and frequently give rise to troublesome and, at times, dangerous complications. The deciduous dentition is usually normal, although occasionally it is delayed. The permanent teeth are very slow to appear; most of them remain unerupted until late in life, and many never erupt, but lie buried in the jaw. The first molars and lower central incisors are the first to erupt; the upper central incisors frequently do not appear. The wearing of artificial dentures seems to stimulate eruption of teeth, even in elderly people, probably from absorption of the overlying bone.

The teeth that do appear are apt to be small, irregularly placed, and crowded, badly embedded, and incompletely erupted. Many of the deciduous teeth remain throughout life and lie among the permanent teeth. The crowns of the erupted permanent teeth are somewhat irregular in outline, with defects in the enamel, dentine, and cement, making them especially subject to caries, periodontoclasia, and hypertrophied gums. The roots are uneven, curved or hooked, and occasionally show spiral twisting. The crowns of the unerupted teeth are spherical or conical in shape, and show pits and elevations due to uneven deposition of enamel.

Absence of some teeth, especially of the upper incisors and molars (and occasionally of the cuspids), is common; supernumerary teeth are frequently seen. The latter, which are usually premolars as far as structure is concerned, are located most commonly in the incisor and premolar areas, and vary in number from two to fourteen.

Dentigerous cysts are often present, and are presumably due to failure of eruption, followed by proliferation and degeneration of epithelial remnants around the crowns of

the teeth. If the cysts are multiple, and in close proximity to one another, they may become confluent. Secondary infection of such cysts has been reported by Fröhlich, and is noted in this report in Case 6.

Upper Extremities

Defects in the clavicles are among the commonest lesions found in mutational dysostosis, and may vary from a small defect in one clavicle to complete absence of both bones. Usually small, bony stumps are present mesially, which articulate with the sternum and to which the sternomastoid and pectoralis major muscles are attached. Frequently both sternal and acromial ends are present, but ununited; occasionally only the acromial ends are present. In about 10 per cent. of all reported cases, the clavicles are entirely absent. In at least one case, three separate bony fragments were present on each side. If small acromial fragments are present, they may articulate with the outer portions of the acromial processes and project out over the shoulder joints. Some authors have reported the presence of fibrous cords between the fragments of clavicle, or between the acromion (or sternum) and the clavicular fragment. Others have commented on the absence of such cords. Occasionally, small defects only are present, with a pseudarthrosis existing between the fragments. In the six cases here reported, small sternal fragments were present in two cases and small sternal and acromial fragments in two; the fifth patient had bilateral sternal fragments but only one (left) acromial fragment. The sixth patient had a small defect in the sternal end of the right clavicle and no defect in the left clavicle.

The scapulae are typically small and of primitive appearance, and lie higher and nearer the axillae than usual, often projecting behind like small wings. The supraspinous fossae are frequently absent, and the acromial processes are wide and long. If the acromial ends of the clavicles are present, the articular facets may be in the usual position or may be on the outer margins of the acromial processes.

Anomalies in the humerus, ulna, and radius are unusual, although the shafts may be somewhat shorter than average. Partial or complete absence of the radius has been reported. More frequent abnormalities are the persistence of epiphyseal lines at the lower extremities of the ulna and radius, and shortening of the radius out of proportion to the ulna, with consequent abduction of the wrist and hand.

Anomalies are common and numerous in the metacarpals and phalanges. In the child, extra epiphyses are encountered in the proximal ends of one or more metacarpals and in the distal ends of one or more phalanges, especially the proximal phalanges. The metacarpals are widened at the ends and narrowed in the shafts; the second metacarpal is usually disproportionately long. The cortex is dense in the constricted areas and is thin elsewhere.

The proximal phalanges are wide above, and narrow and dense distally. The middle phalanges are apt to be short, with slightly concave margins. The terminal phalanges are short and tapering, and lack the normally expanded ungual tuberosities. All phalanges of the little finger are unusually short.

Spine, Pelvis, and Thorax

The spinal abnormalities most frequently encountered are accentuations of the normal anteroposterior and lateral curvatures (lordosis, kyphosis, and scoliosis), fusion defects of the laminae and spinous processes (spina bifida), accessory vertebrae, missing vertebrae, and hemivertebrae. When a hemivertebra is present, as in one of the cases here reported, a marked localized scoliosis results. Cervical ribs are seen occasionally. The lower sacral segments and the coccyx are often absent or defective.

The pelvic bones are usually smaller than normal and have a somewhat primitive appearance, resembling in shape those found in the gorilla. Although small in size, they are thick and heavy, with flaring, asymmetrical iliac crests. The most common defects

are in the ossa pubes, which are underdeveloped and partially deficient mesially. As a result, the symphysis pubis is greatly widened, often measuring several centimeters in transverse diameter. The pelvic canal may be contracted and asymmetrical, which in the female predisposes to difficult or impossible delivery. In spite of these abnormalities, many women have been able to bear children without notably difficult labors, although a few have been delivered by Caesarean section. The wide sacro-iliac joints and symphysis pubis apparently account for the ease of delivery in some cases.

Fusion defects have been noted between the pubic and the ischiatic rami; the posterior inferior spines may be long and narrow, and the acetabula may be shallow.

The ribs are somewhat rounded behind and flattened in front. If spinal anomalies are present, compensatory changes of various types may be noted in the shape and position of the ribs. The sternum may be normal, or it may be small and irregular in outline.

Lower Extremities

The femoral necks are frequently deformed or absent; the infantile type of coxa vara is a common abnormality. While this is usually bilateral, in a few cases it has been present on only one side (often the right), with a consequent short leg and limp. A coxa valga is sometimes encountered. The remainder of the femora, the tibiae, and the fibulae are usually normal, although they may be somewhat shorter than average. Rarely, genu valgum and absence of one or both fibulae have been encountered.

The changes in the ankles and feet are similar to those in the wrists, hands, and fingers. The calcaneus may be shortened and the astragalus may be narrow. Supernumerary metatarsals and digits are occasionally seen.

Muscles

In most cases the muscular development about the neck and shoulders is normal; the muscles which normally are attached to the clavicles are attached to the rudimentary bony stumps or to the fibrous cords, which may be present in place of the deficient bones. Occasionally there is partial or complete absence of the subclavius, the clavicular head of the pectoralis major, the clavicular end of the trapezius, and the clavicular portion of the deltoid. The sternomastoid and sternohyoid muscles are usually present, and are attached to either the rudimentary sternal stumps of the clavicles or to the upper, outer margins of the sternum. The muscles normally attached to the supraspinous fossae of the scapulae are attached to the spines or to the acromial processes. Almost no other muscular abnormalities are found in this condition.

Nervous System

In the majority of cases, the mentality of the patients was reported as normal; neurological and mental lesions were occasionally encountered, however, and a few patients were psychotic or feeble-minded. Brain and cord lesions were reported by several authors, and included syringomyelia, cysts of the frontal lobe, and inflammatory and hemorrhagic lesions of the brain. An autopsy of Stewart's patient showed agenesis of the cingular gyri and of the left caudate and lenticular nuclei. Autopsy examination of one of the author's patients (Case 1) revealed no abnormalities in the brain.

Pressure by the clavicular fragments on the brachial plexus, with consequent neurological symptoms, was reported in at least two cases. In one instance, the symptoms were alleviated by removal of the defective bone.

Miscellaneous Findings

Hematological findings have been variable. Blood-calcium and blood-phosphatase determinations have been, as a rule, within normal limits; blood-phosphorus readings have been normal or slightly low. Blood dyscrasias have been reported, but the majority of the patients have had normal blood pictures. Basal metabolic readings have usually

been normal; a few have been high. Muscular deformities of the feet (talipes cavus and calcaneocavus) and inguinal herniae have been reported. Blue sclera was noted in one case.

General Appearance

The appearance of most of the patients is strikingly similar; in spite of racial differences, there is almost a family resemblance. The dysostotic individual is usually small of stature and slightly underweight, and when standing tends to accentuate the normal anteroposterior curves of the trunk; the head is held forward and the shoulders droop forward and inward. The somewhat overlarge and broad cranium, with prominent bosses and depressed median sulcus topping the small-featured, recessive face and prominent underslung jaw, is seen again and again in photographs of cases reported from all parts of the world. The eyes are widely spaced and sunken; the base of the short nose is broad and flat.

The neck is usually rather long and slopes toward the shoulders. The upper chest lacks the fullness normally present in the clavicular areas. The most characteristic feature of the shoulders is their unusual mobility. While this is largely due to the absence of the supporting and splinting effect of the clavicles, the scapular attachments appear to be much looser than those of normal individuals. In many instances, the shoulders can be bent forward so that they touch or nearly touch below the chin, and many of the case reports contain photographs of patients with the shoulders in this position.

Apparently the defects in the shoulder girdle are of little or no significance as far as function is concerned. No cases were found where patients had complained of difficulty in using their arms or shoulders, either in work or in sports. One of the author's patients was a baggagemaster, who was able to handle heavy trunks and crates without difficulty.

The hands have a rather striking appearance, because of the unusual length of the index fingers and the shortness of the little fingers. The terminal phalanges of all fingers are short and the nails curve in both anteroposterior and transverse diameters.

Clinical Features

Most of the patients are in fair health. Frequently they have consulted their physicians because of some unrelated complaint, and the bone anomalies were discovered in the course of physical examinations.

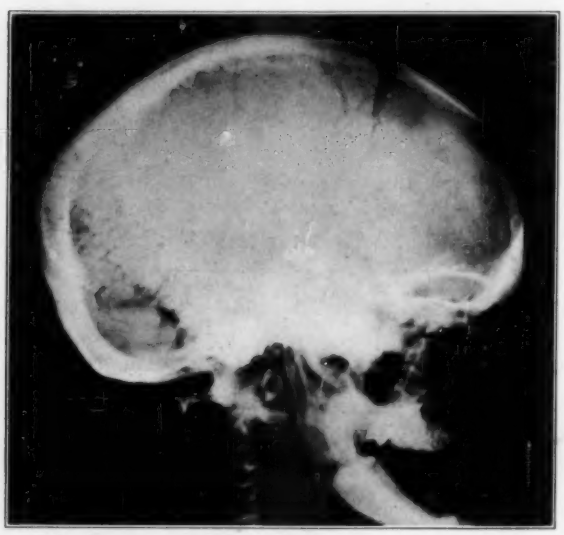

FIG. 1-A

Case 1. Note wide suture lines with wormian bones, underdeveloped facial bones, prognathous mandible, and unerupted teeth.

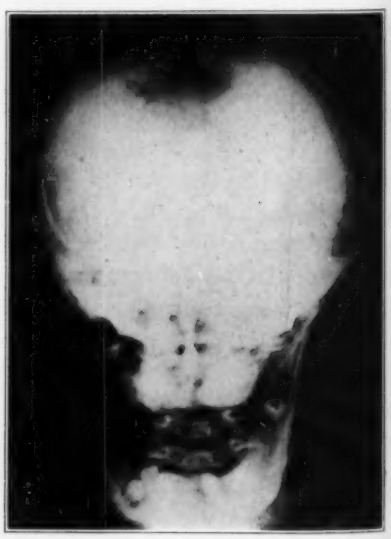

FIG. 1-B

Anteroposterior roentgenogram demonstrates brachycephalia, open fontanelles, and malposed unerupted teeth.

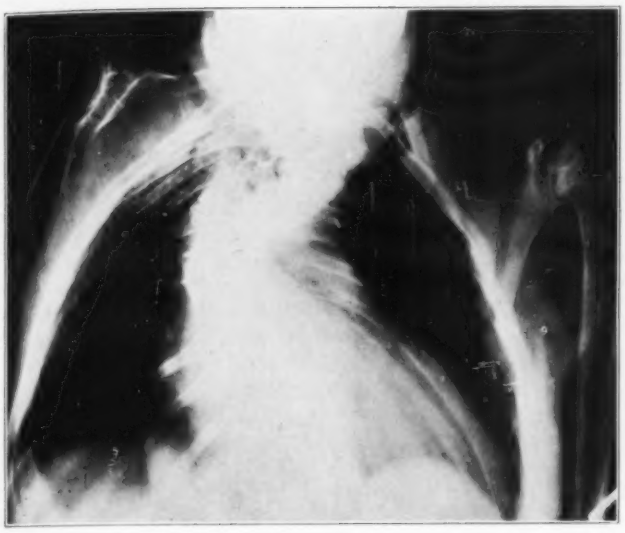

FIG. 1-C

FIG. 1-D

Fig. 1-C: Small right sternal stub of clavicle appears over the first rib. Left sternal stub is concealed by the spine.

Fig. 1-D: Marked thoracic scoliosis is produced in part by a fifth thoracic hemivertebra.

Fig. 1-E: Heads, necks, and lesser trochanters of femora are underdeveloped, and the symphysis pubis is wide.

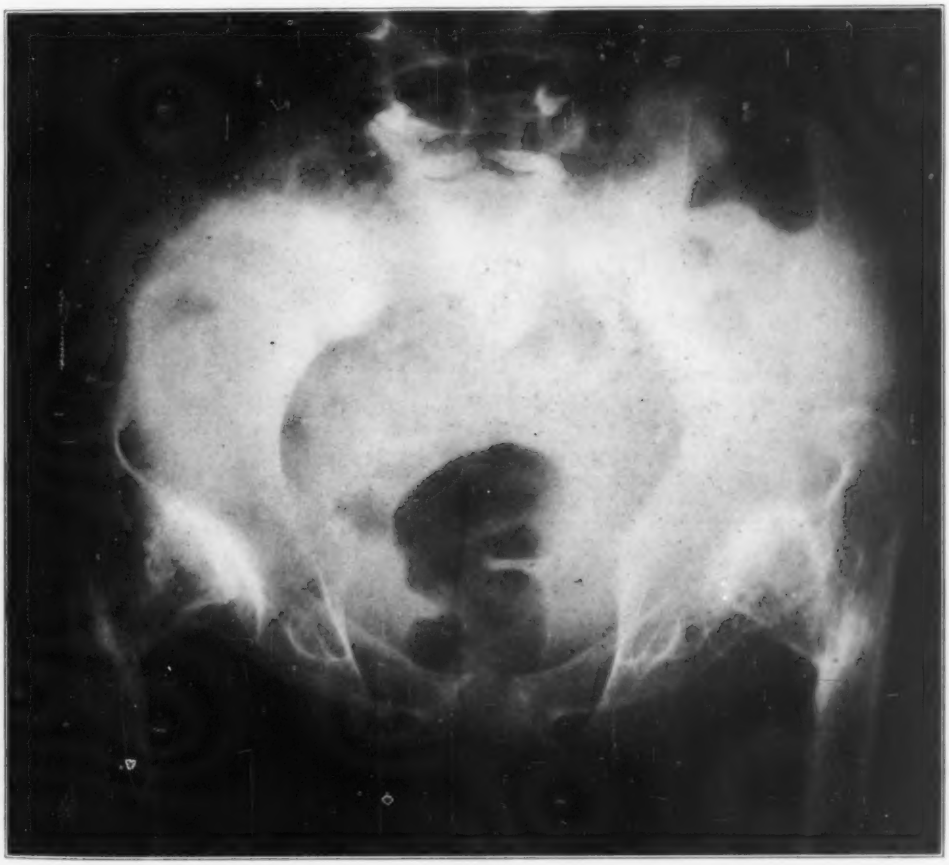

FIG. 1-E

As previously stated, the most troublesome defects are the dental abnormalities, with their attendant complications. If the arches of the feet are poorly developed, or if there are such conditions as genu valgum, coxa vara, or coxa valga (especially if it is asymmetrical), difficulties in gait and posture may be experienced. If the pelvis is contracted, normal labor may be impossible. If spinal anomalies are present, especially hemivertebrae, spina bifida, or extreme lordosis, kyphosis, or scoliosis, symptoms referable to these abnormalities may appear. Treatment is aimed toward alleviation of symptoms produced by the defects.

CASE REPORTS

Case 1. A white male widower of old American stock, a retired baggagemaster, seventy-two years of age, was admitted to the medical ward of the Mary Fletcher Hospital, Burlington, Vermont, on April 10, 1937, in a semicomatose condition. The patient was confused as to time and events, and a satisfactory medical history could not be obtained. Apparently he had been troubled for several months by palpitation, dizziness, dyspnoea on slight exertion, and orthopnoea. At the time of admission to the Hospital, he was moderately dyspnoeic and cyanotic. The cardiac apex impulse was noted in the left fifth interspace, ten centimeters from the midsternal line, and was heaving in character. The apex rate was sixty-two per minute and the rhythm was irregular. The blood pressure was 140/100. An electrocardiogram showed evidence of left bundle-branch block. The tentative diagnosis was coronary sclerosis with probable occlusion.

In the course of the physical examination, it was noted that defects were present in both clavicles, and that the shoulders were unusually mobile. Narrow bits of bone or cartilage, about five centimeters in length, were palpable just above and external to the sternum; the remainder of each clavicle was missing. Palpation revealed the presence of a firm cord or band between the outer end of each bony fragment and the corresponding acromial process.

The cranium was broad, with a depressed furrow extending across the vertex from the glabella to the lambdoidal suture, and with prominent frontal, parietal, and occipital bosses. The face was small and sunken; the lower jaw was prognathous and contained several partially erupted teeth in the incisor region.

The chest was barrel-shaped and there was very little costal movement during respiration. The abdomen was flat and of normal appearance. There was a marked, high thoracic scoliosis and lumbar lordosis. The pelvis was tilted sharply forward. The thighs and legs were emaciated, and a slight genu valgum deformity was present. The fingers on both hands were somewhat misshapen and bent, as if old fractures had healed in abnormal positions.

Within a few days, the patient's clinical condition improved sufficiently to permit a roentgenographic examination of the skull, shoulders, chest, spine, and pelvis. The findings included almost all of the bone defects noted in other severe cases of mutational dysostosis. The skull showed marked brachycephalism, with a cephalic index of 84 degrees, a facial angle of 53 degrees, and a basal angle of 135 degrees. The suture lines were wide and tortuous, enclosing numerous large wormian bones in the lambdoidal and parietotemporal sutures. The coronal and metopic suture lines were open and wide. The facial bones were underdeveloped; defects were present between the malar bones and zygomatic arches. The mandible was prognathous and contained two partially erupted permanent teeth. In addition, there were a number of incompletely developed, unerupted teeth in both upper and lower jaws.

The fifth thoracic vertebra was a hemivertebra, which produced marked localized scoliosis. In addition, there was a long thoracic kyphosis and a lumbosacral lordosis. Fusion defects were present in the posterior arches of the upper three thoracic vertebrae and the fifth lumbar vertebra; the latter was partially sacralized. The pelvis was tilted sharply forward; the symphysis pubis was wide and the acetabula were shallow.

Fig. 2-A

Case 2. Many teeth are deciduous; the permanent incisors are malposed and poorly developed.

There was marked bilateral coxa vara; the femoral heads, necks, and lesser trochanters were underdeveloped. The greater trochanters were unusually large and high.

Bilateral clavicular defects were present. The sternal ends were short and narrow; the acromial ends were short, triangular bones which articulated with the outer margins of the acromial processes. The acromial processes of the scapulae were wide and prominent, and the coracoid processes were small. There was absence of the supraspinous fossae.

The bones of the arms, forearms, and wrists were normal. The second metacarpals were greatly elongated with constricted shafts; the other metacarpals were much shorter. The proximal phalanges were wide and slightly elongated; the middle phalanges were short, with narrow shafts and expanded ends; the distal phalanges were triangular, with underdeveloped terminal tufts.

Blood counts were normal except for the presence of slight anaemia and neutrophilic leukocytosis. The non-protein nitrogen was forty-eight milligrams per 100 cubic centimeters of blood.

The patient improved slightly for several weeks, and then developed signs of myocardial weakness and died on May 2, 1937.

The findings at necropsy were as follows:

One coronary artery was completely occluded by sclerosis, with infarction of the myocardium; the heart weighed 450 grams.

Examination of the skull revealed the findings described. The anterior fontanelle was stellate, depressed, and covered with a thin layer of bone derived from the inner table of the frontal bone; it measured five by ten centimeters in diameter. The mastoid fontanelles were incompletely closed. There was considerable thickening of the calvarium in the regions of the frontal, parietal, and occipital bosses.

FIG. 2-B

FIG. 2-C

Fig. 2-B: Lateral view of skull demonstrates wide suture lines with wormian bones, open anterior fontanelle, prognathous mandible, and multiple deciduous and unerupted permanent teeth.

Fig. 2-C: Showing the open fontanelle and metopic suture.

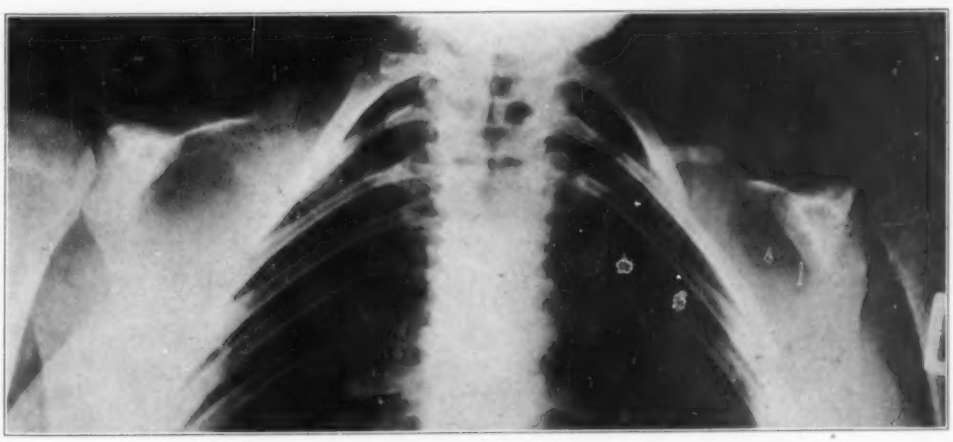

FIG. 2-D

Showing the sternal stubs of the clavicles and fusion defects in the upper thoracic spine.

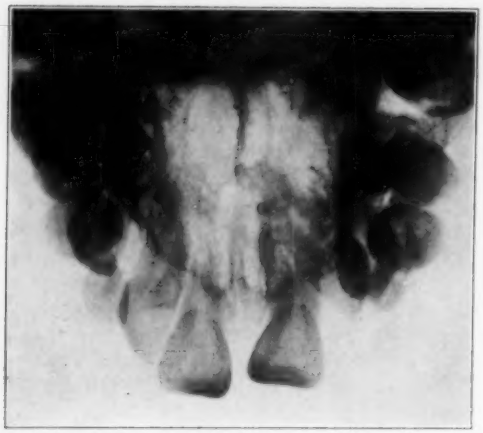

FIG. 2-E
Upper teeth.

FIG. 2-F
Lower teeth.

The sphenoid and temporal bones were small and poorly developed; all of the normal foramina were irregular in outline, but they were not constricted. The mastoid processes were only partially pneumatized, and were composed largely of dense, compact bone. The squamous portions of the temporal bones were thick and dense, and faced downward and outward, forming part of the base of the cranium.

FIG. 2-G
The pelvis is anthropoid in type; the symphysis pubis is wide.

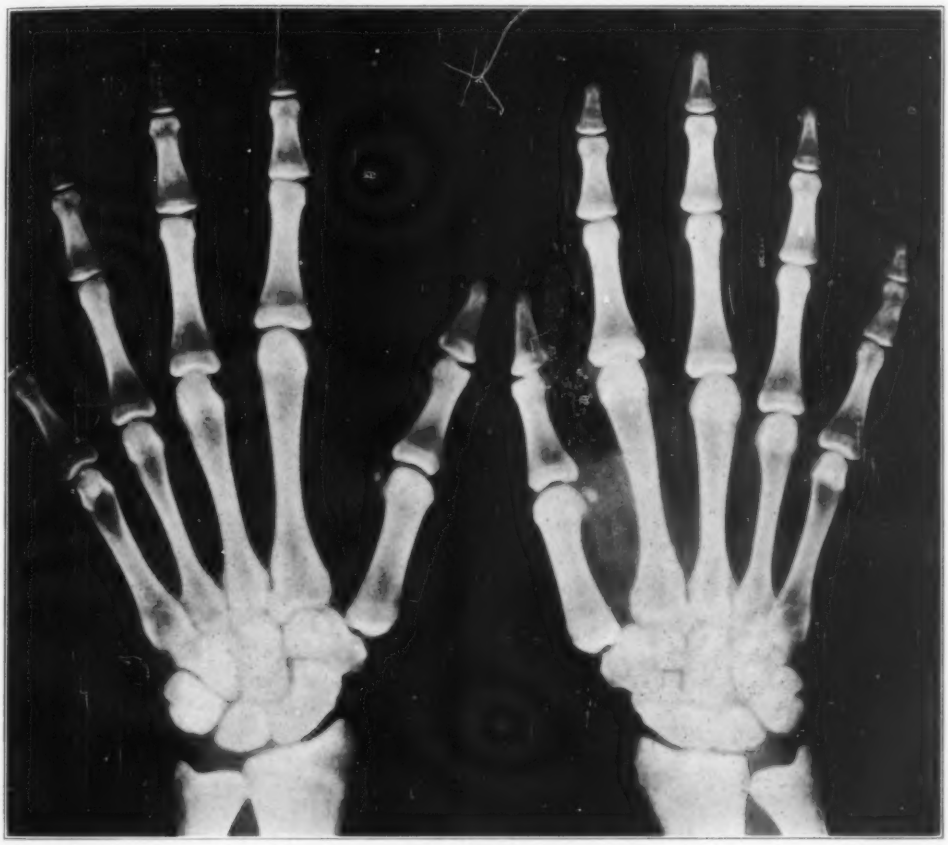

FIG. 2-H

The unusual length of the second metacarpal and the absence of tufts on the terminal phalanges are nearly constant findings in this disease.

The sternal ends of the clavicles were slender, and tapered to rounded lateral points. The right measured 5 centimeters in length and 1.2 centimeters in greatest width; the left measured 5.7 centimeters in length and 1 centimeter in width. The mesial ends articulated with the sternum; the tips were connected with the acromial processes by fibrous bands. The articular facets on the acromial processes were on their lateral margins. The acromial ends of the clavicles were triangular bones, 3.5 centimeters in length and 1.7 centimeters in width across the base.

The muscles which are normally attached to the inner half of the clavicle — the sternomastoid, sternohyoid, and subclavius — were attached to the sternal fragment of the clavicle. The subclavius muscle was greatly enlarged and showed additional attachments to the medial side of the base of the coracoid process of the scapula and to the fibrous band uniting the clavicular fragment with the acromial process.

The ossa pubes were only partially developed, and dense fibrocartilage was present in the region of the greatly widened symphysis pubis. The femoral necks were almost completely absent, the heads being attached directly to the upper shafts.

No developmental abnormalities were noted in the brain or the viscera. In addition to the cardiac disease, there was advanced arteriosclerosis with attendant changes throughout the body, and evidence of terminal congestive failure.

CASE 2 (only child of the patient described in Case 1), a woman, twenty-seven years of age, was examined in the Out-Patient Department. She stated that she knew very little about her father's family; she was aware of no definite case of the same disease in any other relative. She had noticed that she had unusually mobile shoulders, but she did not know that her clavicles were defective. She had always had difficulties with her teeth; the first dentition did not occur until she was two years old, and only a few permanent teeth had erupted at the time of examination. In other respects her health had been good. She had been married at the age of nineteen, and had given birth to a child two years later. Pregnancy and labor had been normal; the latter was of short duration and did not require operative procedure.

Physical examination revealed the typical facies and characteristics of mutational dysostosis. The diagnosis was confirmed by roentgenographic examination. The cranium was brachycephalic with a cephalic index of 82 degrees, a facial angle of 58 degrees, and a basal angle of 146 degrees. The skull showed practically all of the abnormalities noted in her father's. There were numerous unerupted, partially erupted, and malposed teeth, many of which were carious. The eyes were widely spaced, and the nose was broad and slightly recessed. The mandible was slightly prognathous.

The neck sloped downward to the shoulders, which were narrow and sagging, and faced slightly forward and inward. The shoulders were unusually mobile, and could be brought forward so that they nearly touched in front. Short sternal ends of the clavicles could be easily felt and seen; the right was four centimeters in length and the left was six centimeters. No acromial ends could be palpated or visualized by roentgenogram. There was no palpable evidence of connecting cords or other structures between the rudimentary clavicles and scapulae. The scapulae and bones of the upper extremities showed abnormalities similar to those noted in her father. The patient also showed multiple defects in fusion of the vertebrae, but no hemivertebrae or other spinal deformities were visualized.

FIG. 2-I

FIG. 2-J

Fig. 2-I: The talus and calcaneus are small and poorly developed.
Fig. 2-J: Showing blunting of tips of terminal phalanges of toes.

The pelvis was small and anthropoid in type. Large defects were present in the inferior pubic rami, with consequent great widening of the symphysis pubis. The postero-inferior iliac spines were elongated, and the sacro-iliac joints were wide and irregular in outline. There was slight bilateral coxa valga; the tarsal bones were short and the phalanges of the toes showed changes similar to those noted in the fingers.

The patient's seven-year-old daughter was examined and showed no abnormalities in skeletal, soft tissue, or dental development.

FIG. 3-A

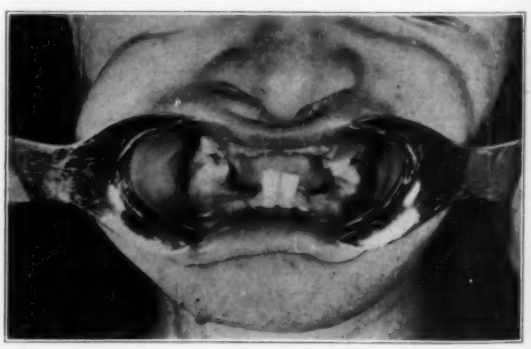

FIG. 3-B

Fig. 3-A: Case 3. The defects in the clavicles allow unusual mobility of the shoulders.
Fig. 3-B: Most of the deciduous teeth have been extracted and only a few permanent teeth have erupted.

CASE 3. A corporal, twenty-six years of age, received multiple shrapnel wounds of the neck, thorax, left hand, and ankle, while serving as a paratrooper in France. After several months of hospitalization overseas, he was returned to the United States with a partially healed compound fracture of the left calcaneus and with healed amputations of the left thumb and several fingers. Upon admission to the overseas general hospital it had been discovered that he had cleidocranial dysostosis.

FIG. 3-C

FIG. 3-D

Fig. 3-C: The cranial vault appears unusually large in comparison with the facial bones; wormian bones are present in the wide, tortuous sutures. An open mastoid fontanelle is visible.

Fig. 3-D: Brachycephalia and metopic suture are apparent.

The skull was brachycephalic, with a moderately kyphotic base and deep posterior cranial fossa. Small ovoid defects were present in the middle of an ununited metopic suture and in the regions of the mastoid fontanelles. Numerous wormian bones were present in the lambdoidal suture. The facial bones were underdeveloped and recessed. All of the deciduous, and many of the erupted permanent teeth, had been extracted. The remaining molar teeth were short and only partially erupted, and had a few enamel defects in the crowns. Roentgenograms demonstrated numerous unerupted and partially developed teeth in both upper and lower jaws.

There was complete absence of the lateral halves of the clavicles; the outer ends of the medial fragments were slender with rounded tips. Fibrous cords, connecting the stumps of clavicles and acromial processes, could be palpated. The scapulae lacked supraspinous portions but had un-

FIG. 3-E

FIG. 3-F

Fig. 3-E: The sternal stubs of the clavicles, fusion defects in the upper thoracic vertebrae, and abnormalities in the scapulae are visualized.

Fig. 3-F: The bones of the hand and fingers have an appearance similar to that noted in Fig. 2-H.

usually large, wide, and long acromial processes. There was characteristic hypermobility of the shoulders (Fig. 3-A).

Fusion defects were present in the posterior arches of the lower two cervical vertebrae and of the upper three thoracic vertebrae. The fifth lumbar vertebra was partially sacralized, with large transverse

FIG. 3-G

Showing structural abnormalities in the ilia and ossa pubes.

FIG. 4-A

Case 4. Lateral view of the skull demonstrates large anterior fontanelle and small mastoid fontanelle, wormian bones, prognathism, and supernumerary teeth.

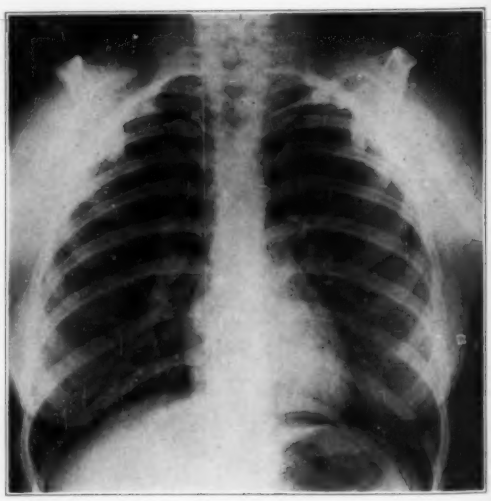

FIG. 4-B

The slender sternal ends of the clavicles are faintly visualized. Unusual mobility of the shoulders allows the scapulae to rotate anteriorly.

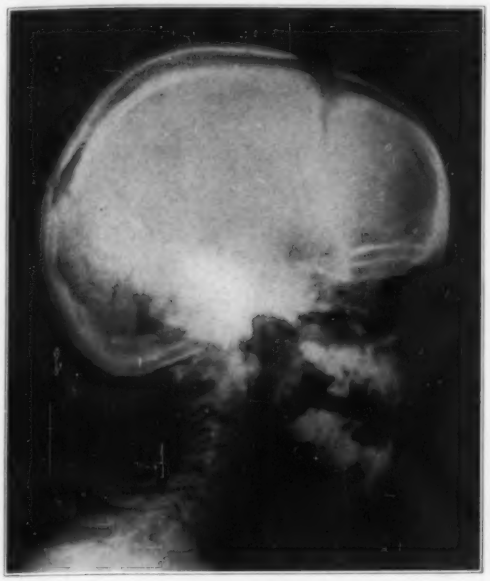

FIG. 5-A

Case 5. Large anterior, posterior, and mastoid fontanelles are visible.

FIG. 5-B

Demonstrating the sternal ends of the clavicles and rotation of the scapulae.

processes articulating with the ilia and sacrum. The ilia were slender with high sloping crests. The bodies and rami of the ossa pubes were asymmetrical and irregular in outline, and there was slight widening of the symphysis pubis. Small accessory bones were present opposite the postero-inferior iliac spines.

There was moderate bilateral coxa valga. The femoral and tibial condyles were underdeveloped, the ends of the femora and tibiae being only slightly wider than the metaphyses.

There was characteristic lengthening of the second and third metacarpals and metatarsals, and of the proximal phalanges of the fingers and toes. The terminal phalanges were long and pyramidal in shape, with small terminal tufts. Although the epiphyses of the long and short bones were fused, narrow zones of bone sclerosis were present at the sites of the epiphyseal lines.

The patient was small in stature, but muscular and wiry. He was intelligent and alert, and had made an excellent combat soldier. He stated that his parents, grandparents, and several brothers and sisters were normal, and that he knew of no relatives who had abnormalities similar to his.

Two cases (Cases 4 and 5) appearing in a brother and sister were diagnosed in the course of a routine survey of school children, and were contributed through the courtesy of Dr. Louis Benson of the Vermont Tuberculosis Association. Inconclusive data are available regarding other members of the family. The father was said to have been normal in appearance; by a previous marriage he had had two normal children. The children's mother was not examined, but was reported by the public health nurse to have had facial characteristics and sloping shoulders similar to those noted in the children. One other child was said to be normal.

CASE 4. This fifteen-year-old girl had a brachycephalic skull. The metopic suture was ununited and the anterior fontanelle was open. Numerous wormian bones were present in the sagittal and lambdoidal sutures. There were many supernumerary unerupted permanent teeth, and most of the deciduous teeth still remained. The facial bones were underdeveloped, the base of the skull was kyphotic, and the mandible was prognathous.

There was a complete central defect in the left clavicle, with underdeveloped sternal and acromial stumps. On the right, a small sternal stump was present, but no acromial fragment had developed. Fusion defects were present in the posterior arches of the first and second thoracic vertebrae. The pelvis was anthropoid in type with slender, irregular ilia. There was absence of the descending rami of the ossa pubes and widening of the symphysis pubis.

CASE 5. This patient, a boy thirteen years of age, had somewhat similar findings. In addition to

FIG. 6-A

FIG. 6-B

Fig. 6-A: Case 6. The fingers are short and broad, and the nails show moderate onychogryposis.
Fig. 6-B: Changes somewhat similar to those noted in the fingers are present in the toes and toenails.

FIG. 6-C

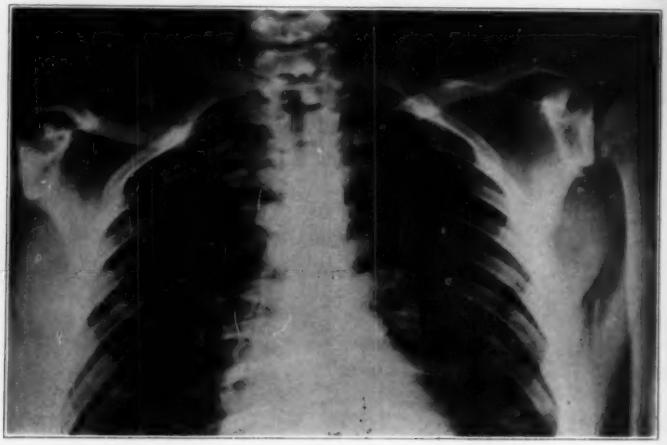

FIG. 6-D

Fig. 6-C: Characteristic changes are present in the metacarpals and phalanges.
Fig. 6-D: The right clavicle shows a small medial defect.

brachycephalia, open sagittal and metopic sutures and anterior fontanelle, the base of the skull was unusually kyphotic and the foramen magnum faced forward and only slightly downward. Central clavicular defects were present, and there was failure of fusion of the posterior arches of the seventh cervical vertebra and the upper six thoracic vertebrae. There was complete absence of both ossa pubes, but the remainder of the pelvis and the upper femora were of normal appearance.

CASE 6. A soldier, aged thirty-seven, was returned from overseas to Halloran General Hospital, because of impacted and unerupted teeth in the maxillae and mandible, with an infected dentigerous cyst in the mandible.

The patient was one of seven children; his parents, four sisters, and two brothers were free from evidences of dysostosis, as far as he knew. He had always enjoyed good health, with no complaints other than those relating to his teeth. The patient gave rather vague information about dentition, but stated that he had always had trouble with his teeth,—that they were poorly spaced in childhood and subject to caries, and that many of them were extracted early in life. He believed that only a few permanent teeth had ever erupted.

At the time of enlistment in the Army in 1937, the patient had eight erupted teeth,—six lowers and two uppers. These teeth were extracted in 1942, and he was fitted with dentures, which he has worn since. He had no further dental symptoms until June 1945, when severe pain in the right lower jaw developed. Roentgenographic examination in the dental department of an overseas Army Hospital revealed fourteen unerupted and poorly developed teeth in the maxillae and ten similar teeth in the mandible. Small cysts were noted about a number of these teeth. In view of the major dental problem involved, the patient was evacuated to the United States; examination revealed an infected dentigerous cyst, which was opened and drained.

FIG. 6-E

Showing brachycephalia, a metopic fontanelle, depressed sagittal suture, and unerupted teeth.

FIG. 6-F

Demonstrating wormian bones, prognathism, and poorly developed unerupted teeth.

Physical examination showed a man, short in stature (sixty-one inches tall), but fairly well developed, with evidence of good nourishment. The head was moderately brachycephalic; facial features were slightly recessive, and the mandible was slightly prognathous. There were no erupted teeth, and the patient was wearing dentures.

No significant abnormalities were noted in chest, shoulders, or abdomen. The fingers and toes were slightly short, especially the terminal phalanges, with a tendency toward clubbing. The nails showed a rather marked degree of onychogryposis,—more prominent in the toes than in the fingers. The nails were thickened, lacked luster, and were partly separated from the nail beds at the free edges.

Roentgenograms showed characteristic findings in all bones except the clavicles. There was moderate depression of the sagittal suture, and an ovoid defect was present in the lambdoidal suture. The bones of the face and of the base of the skull were underdeveloped; the mandible was large and prognathous. Most of the unerupted teeth resembled poorly formed cuspids, and had underdeveloped roots and irregular crowns.

The left clavicle was completely developed and showed no defect. The sternal end of the right clavicle was deficient, the bone ending medially in a rounded point. The scapulae showed slightly prominent supraspinous portions. Each os innominatum was slender and poorly developed; there was bilateral coxa valga.

The second metacarpals and metatarsals were unusually long, and the terminal phalanges of fingers and toes showed underdeveloped terminal tufts. There was an anomalous ununited epiphysis at the base of the second metatarsal.

COMMENT

In reviewing the descriptions of the developmental defects reported in the mass of material covered, one is impressed by the multiplicity and variability of lesions found in this disease. While certain bones, especially the clavicles and skull bones, have been involved in nearly all cases, there have been patients with mutational dysostosis in which these bones have been normal. Rhinehart's patient had normal clavicles, but characteristic lesions were present in the skull. Fitchet reported defective clavicles in six members of one family (three generations) all but one of whom had normal skulls,—the one exception, the youngest child, had delayed closure of the anterior fontanelle, wide suture lines, and a slightly prognathous jaw. In the author's Case 6, the patient had a small defect in one

clavicle only—and that at the extremity of the bone rather than in the mid-shaft—while characteristic lesions were noted elsewhere in the skeleton.

Therefore, the author agrees with Rhinehart that the term "cleidocranial dysostosis" should be replaced by the more accurate and descriptive term, "mutational dysostosis", and believes that the condition should be considered as one in which any or all of the many different defects may occur. As the condition is traced through additional generations of families, a better understanding should be reached concerning the factors of heredity which operate in its transmission.

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ARTHRODESIS OF THE HIP PRODUCED BY INTERNAL FIXATION

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During the past twenty-five years, orthopaedic surgeons have expended much effort on the problem presented by the elderly patient with painful, disabling arthritis of the hip. New surgical operations, such as acetabuloplasty, have been devised; and older operations, such as arthroplasty, have been modified. Although a great deal of good work has been done, there is still no completely satisfactory answer to the problem. The conventional method of arthrodesis, necessitating prolonged spica immobilization and inevitably resulting in a stiff knee, is not well tolerated by older patients. Furthermore, many patients who are not adverse to having an operation will instantly reject the idea of being bedridden in a cast for three or four months. A method was therefore sought for stabilizing the hip, which, without plaster immobilization, would permit early ambulation.

In 1935 Burns reported one case in which he had used a tri-flanged nail to fix the hip, and four years later he reported twelve more cases which were similarly treated. Six of these patients obtained a painless hip; one died of pulmonary embolism; one had no relief from pain; two suffered subtrochanteric fractures; and two patients had recurrent pain when the nail slipped. Watson-Jones reported "favorable results" in thirteen patients with malum coxae senilis treated by arthrodesis. Both of these authors used a tri-flanged nail, driven through the head of the femur and into the ilium over a guide wire from the subtrochanteric region. The position of the nail was checked by anteroposterior and lateral roentgenograms. Extrusion of the nail was prevented by a pin which fixed it to the lateral femoral cortex. No cast was applied, and the patients were ambulatory in ten days. No evidence was presented as to whether or not bony ankylosis developed. White operated upon seven hips which he fixed by nailing; two of the patients had an active tuberculous coxitis. Results were reported as encouraging.

Stimulated by the reports of Burns and of Watson-Jones, the authors performed the operation on several fresh cadavera. Fairly firm, immediate fixation could be obtained with the nail alone, but *both the rigidity and the strength of the fixation were greatly increased by inserting a screw through the acetabulum into the head, at right angles to the nail.*

The operative procedure described here has now been used a number of times, and the present state of the first twenty-four patients treated in this manner is recorded.

In this series, there were ten women and fourteen men. The youngest was twenty-one and the oldest seventy-one years of age; the majority were over fifty years old. Pain in the hip, thigh, or knee was the main complaint in all cases, and it was for this, rather than for any deformity, that the patients sought treatment. One patient was bedridden because of severe pain; others could get about only with the aid of crutches. None could work. Active flexion in the affected hips ranged from 40 degrees to 1 or 2 degrees in patients with a firm, fibrous ankylosis. Abduction, adduction, and rotation were usually impossible. The deformity of the affected extremity was usually one of adduction and external rotation. Severe adduction in some cases resulted in marked apparent shortening. The Trendelenburg test was positive in all cases. In only one patient was hypertrophic arthritis marked in both hips; in this patient, treatment of the less involved hip has not been necessary. Aside from their age, all patients were good operative risks.

Roentgenograms in all cases showed narrowing of the joint space, degenerative cystic changes in the sclerotic bone, and hypertrophic changes about the acetabulum. Shortening of the femoral necks and partial subluxation of the more severely deformed, flattened femoral heads existed to varying degrees.

Two of the patients had painful hips, one following a Smith-Petersen acetabuloplasty

and the other following a vitallium-cup arthroplasty. Three patients had traumatic arthritis. The remaining nineteen patients were diagnosed as having hypertrophic arthritis of the hip.

OPERATIVE TECHNIQUE

The patient is placed in the supine position, with the hip well toward the edge of the table. To ensure that the hip will be arthrodesed in the desired degree of flexion, sandbags are placed beneath the knee, and fixed to the operating table with adhesive tape before the extremity is prepared and draped. The draping is applied so that the limb is free, and so may be manipulated by the operator.

An incision is curved over the anterior half of the iliac crest, and carried longitudinally five inches down the anterior surface of the thigh, exposing the iliac crest and sartorius. The latter muscle is detached at its origin and reflected medially. With a periosteal elevator, the tensor fasciae latae and the anterior origins of the gluteus minimus and the gluteus medius are elevated and reflected laterally. The tendinous portion of the rectus femoris is divided close to the anterior inferior iliac spine, and the muscle is allowed to retract. The anterior surface of the capsule of the hip joint is exposed and incised transversely. The iliac part of the incision is then packed with sponges to control oozing.

The attachments of the abdominal muscles to the iliac crest are elevated, and subperiosteal dissection is carried beneath the iliacus muscle to below the arcuate line. Exposure of the iliac fossa is facilitated, if an operating table is used which can be tilted transversely, thus causing the abdominal wall and its contents to fall away from the operated side of the pelvis. This exposes the internal side of the innominate bone from the iliopectineal eminence almost to the sacro-iliac joint.

The hip is dislocated. The remaining cartilage and fibrous tissue are chiseled from the head of the femur and the acetabulum, and the denuded head of the femur is then replaced into the acetabulum.

Another incision is made through the skin, the fascia lata, and the vastus lateralis, exposing three inches of the femur in the subtrochanteric region. With a sharp gouge, the cortex is opened about one inch below the greater trochanter to receive the Smith-Petersen nail. Care must be taken not to destroy too much of the cortex, or the stability of the nail will be reduced. With the hip flexed 35 to 50 degrees and in the mid-position (adduction-abduction), the nail is driven through the femur and into the thick part of the innominate bone. An assistant places his hand in the iliac fossa so that it can be determined when the nail protrudes through the inner cortex of the pelvis. The exact angle at which the nail is inserted depends on the deformity and degree of subluxation of the head of the femur. In order to traverse the thick section of the ilium, it must, in most cases, transect the anterior superior portion of the femoral head. The femur is then impacted firmly into the acetabulum.

A hole is drilled through the pelvis and into the femoral head from the inner surface of the ilium in the region of the anterior inferior iliac spine. A Venable screw, three and one-half inches long, is inserted to prevent rotation of the head.

At this point the joint should be completely stable. If motion can be demonstrated on even vigorous manipulation, the operation will be a failure.

The fascia over the iliac crest is brought together with several interrupted sutures, reinserting the lateral and abdominal muscles, and the skin is closed. No cast is applied. A transfusion of 500 cubic centimeters of blood is administered during the operation.

COMMENTS ON OPERATIVE TECHNIQUE

It is imperative to use a sharp-pointed nail. A blunt nail penetrates the sclerotic ilium with difficulty, and may eject the femoral head, along with the nail, out of the

acetabulum. As an added precaution, the head is vigorously impacted into the depth of the acetabulum to assure continuity of the raw surfaces of the femur and the acetabulum. This is essential for the development of bony union.

It is most important that the nail, to secure fixation at its distal end, be driven through the thick part of the ilium which forms the anterior superior surface of the acetabulum. The ilium in this area is about one inch thick, in contrast to the few millimeters of bone composing the medial, central wall of the acetabulum (Fig. 1). The nail must be inserted into the femur at an angle of about 45 degrees, and directed slightly anterior. The exact angle depends on the amount of deformity and subluxation of the femoral head. If the nail is directed through the posterior inferior quadrant of the femoral head, it will pass through the thin portion of the acetabulum and well below the arcuate line, and may pass undetected into the pelvic cavity. Likewise, if the nail is inserted into the femur at an angle of much less than 45 degrees, it may strike the ilium too acutely and sheer off rather than penetrate the bone.

FIG. 1

Frontal section of hip, demonstrating the course of the Smith-Petersen nail through the femur and into the thick portion of the pelvis, overlying the acetabulum.

In the authors' experience, 35 degrees to 50 degrees of flexion is desirable. Less flexion than this makes it difficult for the patient to sit. Although it has been suggested that the lumbar lordosis will permit adequate flexion if arthrodesis is performed with the patient's leg extended on the operating table, a few patients treated in this manner by the authors complained of inability to sit comfortably. No patient had complaints resulting from too much flexion. To facilitate placing the hip in adequate flexion, and in the neutral position with respect to abduction and adduction, heavy sandbags were placed beneath the knee before the limb was draped. Sandbags could not be employed when the hip was fixed by a firm fibrous ankylosis in partial flexion or marked adduction. Difficulty was encountered, especially with obese individuals, in estimating the degree of abduction or adduction. No hip was arthrodesed in abduction. A few were placed in adduction, but the shortening which resulted was easily taken care of by a lift on the patient's shoe.

In the first patients operated upon, a small-gauge screw was used, which fractured in one case (Fig. 8) and bent in another (Fig. 9). At present a large vitallium Venable screw, three and one-half inches in length, is utilized, which adds greatly to the stability produced by the operation. Ideally, the screw penetrates one and one-half inches into iliac bone, and extends through the center of the head of the femur (Figs. 2, 3-A, and 3-B).

One fundamental variation in operative technique was tried on two patients who had a very firm fibrous ankylosis with a minimal degree of deformity. The hips were fixed with a nail and screw, without being dislocated. Several different surgical approaches were tried, but the one described proved most satisfactory. In a few instances extra-articular bone grafts secured from the iliac crest were used to ensure the ankylosis.

POSTOPERATIVE CARE

Most patients withstood the operative procedure well, and they were encouraged to move about in bed as soon as possible. They were usually up in a chair on the seventh day after operation. By the tenth day they were encouraged to use crutches, and were dismissed on crutches usually between the tenth and fourteenth days. If the hip was solidly fixed, they could bear full weight on the operated leg without pain. None of the patients who had painful hips when dismissed from the hospital secured a solid ankylosis. It is certain that a solid operative fixation was not achieved in these failures.

An effort was made to have all patients use crutches for two or three months after the operation; however, some patients discarded them earlier.

DISCUSSION

Fifteen of twenty-four patients operated upon obtained painless, stable hips (Table I).

TABLE I

RESULTS OF OPERATION

	Number of Patients
Painless stable hip	15
Pain and motion in hip	7
Wound infection	1
Postoperative deaths	1

Seven had motion and pain in their hips after operation. There was one postoperative death, which was caused by a pulmonary embolism. One wound infection necessitated removal of the nail and screw. The wound healed and a bony ankylosis resulted.

Three of the seven failures (Table II) were probably the result of fracture of the nail (Fig. 8). Two of these patients experienced a sudden sharp pain in the hip after a fall; however, the other patient could remember no instance of excessive strain upon his hip.

FIG. 2

Section through ilium and head of femur, demonstrating position of Venable screw.

FIG. 3-A

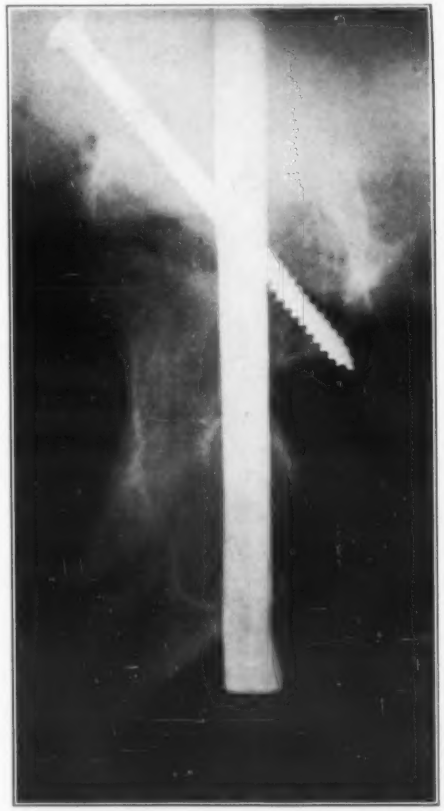

FIG. 3-B

Fig. 3-A: Postoperative roentgenogram, demonstrating the Smith-Petersen nail well fixed in iliac bone. The Venable screw, extending through the femoral head, eliminates rotation in the anteroposterior plane and prevents the femur from pulling away from the acetabulum.

FIG. 3-B: Lateral roentgenogram, showing that the screw does traverse the femoral head.

FIG. 4-A

FIG. 4-B

FIG. 4-C

Fig. 4-A: S. W. Preoperative roentgenogram, showing changes typical of hypertrophic arthritis.
Fig. 4-B: Postoperative roentgenogram. The hip is solidly fixed by a nail and two small vitallium screws.
Fig. 4-C: Roentgenogram taken three years and eleven months after operation. Bony trabeculae extend across the joint. The patient works as a laborer, and has no symptoms.

FIG. 5-A

FIG. 5-B

FIG. 5-C

Fig. 5-A: F. J. L. Postoperative roentgenogram of hip well stabilized by vitallium nail and screw.
Fig. 5-B: Six months after operation the joint space is still visible. Clinically the hip was solidly arthrodesed.
Fig. 5-C: One year and eight months after operation. Bony trabeculae extend across and obliterate the joint space, demonstrating that bony ankylosis can occur while the patient is ambulatory.

FIG. 6

M. S. Three years and five months after operation. A bridge of bone extends from the acetabulum to the femoral neck and head. The patient walks with no limp.

FIG. 7

A. D. Four months after operation. The hip is well fixed by a vitallium nail and screw. Clinically the hip is firmly arthrodesed.

FIG. 8

C. J. This patient fell down a flight of stairs eight weeks after operation, and experienced severe pain in his hip. The nail and screw evidently broke at that time, because he walked without pain before the fall.

walks with no limp.

broke at that time, because he walked without pain before the fall.

FIG. 9

W. R. Postoperative roentgenogram. The nail was inserted into the ilium too acutely. Adduction of the limb in bed caused the nail to sheer out and one screw to bend.

FIG. 10

J. L. Two and one-half years after operation. There is absorption of bone about the nail, allowing 40 degrees of hip flexion and extension.

FIG. 11

Nineteen months after operation, showing absorption around point of nail and aseptic necrosis of femoral head.

Pain and motion increased gradually. Another operation failed because the nail penetrated the pelvis too acutely, and sheered out when the patient moved in bed (Fig. 9). Resorption around the nail allowed motion in the hip in another case (Fig. 10). Aseptic necrosis of the remaining femoral head prevented ankylosis in one patient, who had previously been treated by a vitallium-cup arthroplasty. In another patient, in whom bony ankylosis did not occur because of inadequate fixation at the time of operation, necrosis of the femoral head eventually developed (Fig. 11). The longest follow-up period was four and one-half years; the shortest was six months.

TABLE II

CAUSE OF FAILURE

	Number of Patients
Broken nail	3
Nail incorrectly inserted	1
Resorption around nail	1
Aseptic necrosis of head of femur	1
Motion in hip after operation	1

Since three of seven failures can be attributed to fracture of the vitallium nail, this factor could perhaps be remedied by the use of a stainless-steel nail, which is less brittle. Because of similar experiences, Watson-Jones employs an oversize nail.

Of the fifteen patients who obtained good results, eight were men and seven were women. Two of the women use crutches when outside of the house, because of arthritic changes which developed in the other hip. One uses a cane for walking long distances. The eight men are working full time as laborers and have no pain in the hip.

Not all of the patients with satisfactory results have a bony ankylosis demonstrable by roentgenogram. The joint space may be discernible in roentgenograms for some time after the operation. Figures 5-A, 5-B, and 5-C demonstrate that six months after operation the joint space is still visible, but by twenty months bony trabeculae extend across the joint space.

Gross circulatory disturbances in the head of the femur may preclude a bony ankylosis, even though the hip is solidly fixed and raw bony surfaces are in contact. In these cases extra-articular grafts, turned down from the ilium to the femoral neck, increase the chance of a bony fusion.

CONCLUSIONS

The procedure described should be limited to older patients who have degenerative or traumatic arthritis of the hip. Marked aseptic necrosis, and a wide disparity of configuration between the head of the femur and the acetabulum, are definite contraindications.

A vitallium screw placed through the acetabulum and into the head of the femur adds greatly to the stability secured by the Smith-Petersen nail. If there is motion in the hip at the end of the operation, this will increase as the patient moves about. To ensure complete stability, the nail must penetrate the thick part of the acetabulum.

This procedure provides immediate hip fixation and allows the patient to be up two weeks after operation.

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VERTICAL TRACTION IN THE EARLY MANAGEMENT OF CERTAIN COMPOUND FRACTURES OF THE FEMUR

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The treatment of compound comminuted fractures of the femur often requires more care for the soft tissues of the thigh than for the femur itself. The usual position of the extremity on the operating table, or on a special orthopaedic table, does not give circumferential access to the thigh for surgical procedures. The conventional methods of traction do not permit ready access to the posterior wounds which are so frequently present in the thigh. As an aid to operative management and as a temporary method of traction for the first few weeks after the operation, the vertical "90-90-90 traction" was devised and was found to be satisfactory.[1] Essentially, this method consists of exerting traction on the femur while the hip, knee, and ankle are each flexed at 90 degrees.

In the operating room an overhead frame may be improvised by clamping a cross bar to two wooden transfusion stands, one at each end of the table. A pulley is attached to the cross bar directly over the hip of the involved extremity. A Kirschner wire is inserted just above the condyles of the femur, or, if wounds involve the lower thigh, it is inserted in the tibial tubercle, and traction is directed over the pulley so that the femur is held at right angles to the table. Enough pull is exerted to lift the buttock slightly off the table, and the traction cord is fastened to the transfusion stand at the head of the table. The proper position of the knee and foot is best obtained by applying a piece of stockinette to the leg, splitting it under the heel to prevent its slipping off, and tying the loose end to the cross bar above the toes. If skeletal traction is not available or feasible, the position of vertical traction can be obtained by a suitable sling under the calf (Fig. 1).

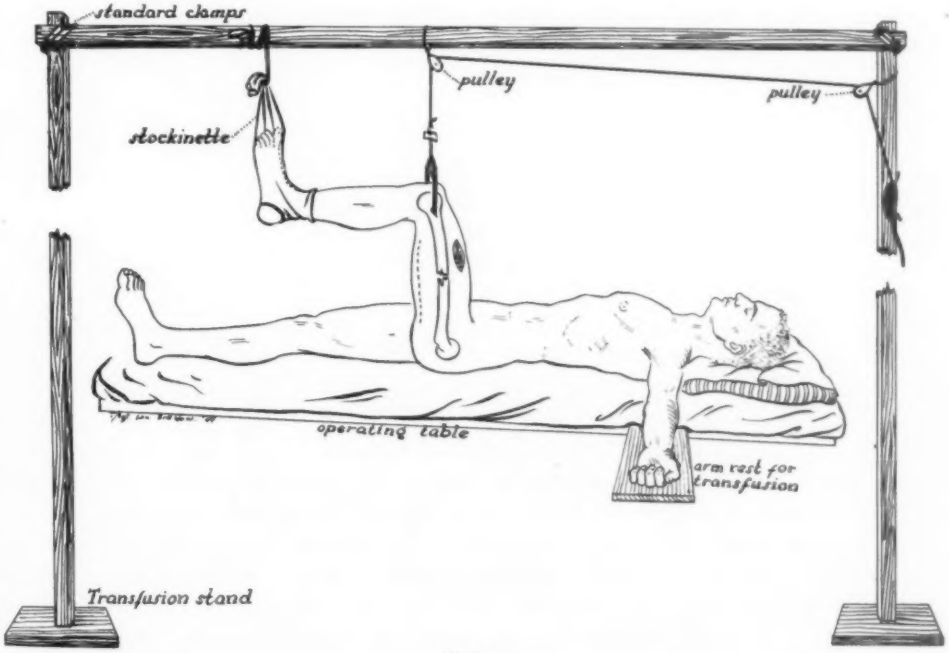

FIG. 1

Position of patient in 90–90–90 traction for surgery. The Kirschner wire may be placed in the upper tibia or lower end of the femur. If skeletal traction is not available, this position may be maintained by slings under the leg.

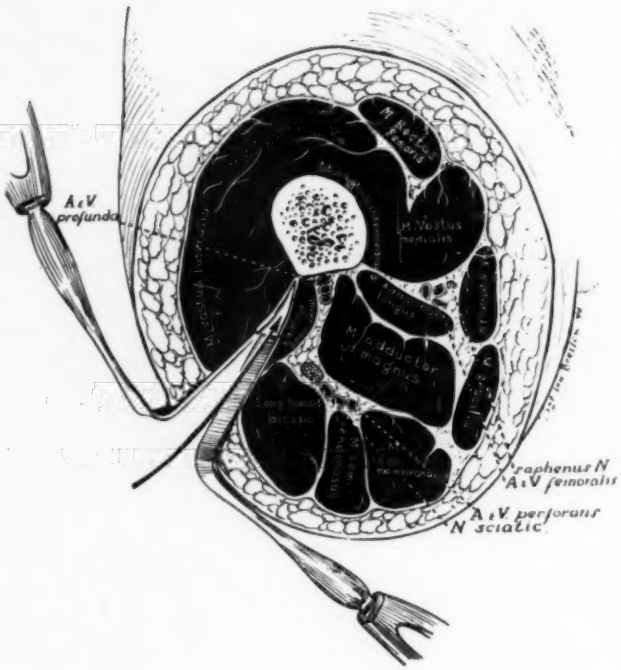

FIG. 2

Posterolateral approach to the femur between the vastus lateralis and biceps femoris. Mid-third of right thigh (after Gray).

Experience with over 250 battle fractures of the femur has proved the value of this method of traction in the operative management of the fracture. The great frequency of multiple and extensive wounds of the soft tissues, especially combined anterior and posterior wounds, makes it necessary to approach the thigh from every direction. Traction to the femur with the hip flexed at 90 degrees allows excellent circumferential access to the thigh, and permits wounds at any location to be approached with ease. By maintaining a steady and uninterrupted pull on the femur, this method prevents unguarded motion at the fracture site during the preparation and draping of the extremity, and at the same time corrects the overriding of the fracture ends.

In the initial débridement of the soft-tissue wounds, vertical traction permits the entire operation to be carried out with the patient on his back. To change the patient from the supine to the prone position during the operation, in order to explore and débride posterior thigh wounds, requires additional handling of the fractured extremity, as well as additional preparation and draping of the thigh. Not only is this time-consuming, but further injury to the soft tissues, vessels, and nerves by the fracture fragments may result.

In the reparative management of this fracture in a base hospital, the patient is brought to surgery in a spica cast or a Tobruk splint. After anaesthesia has been induced, the anterior half of the cast is removed, a Kirschner wire is placed in the distal femur or proximal tibia, and the extremity is suspended in 90-90-90 traction. The posterior half of the cast is then withdrawn, and the thigh can be shaved, washed, and draped without risk of displacement of the fracture.

Despite a careful débridement, there is often an accumulation of blood, tissue debris, and even pus in the wound. Provisions for dependent drainage of dead space must be made. In the author's experience, a posterolateral approach to the femur between the vastus lateralis and the biceps femoris is the best incision for this purpose (Fig. 2), and is facilitated by having the femur in vertical traction. It is also a valuable elective approach to the fracture site for open reduction and internal fixation of the occasional compound fracture which lends itself to this type of surgery. Excellent exposure is obtained by this route, and dependent drainage is assured, if the proximal portion of the incision is left open for spontaneous closure. Invariably the wound is completely healed by the time the fracture is united.

This method of traction is also employed for the external skeletal fixation of selected fractures, using the pins and couplings of the Roger Anderson apparatus. The fracture is reduced by 90-90-90 traction before the pins and couplings are applied. The reduction can often be confirmed by direct vision or palpation, but may be checked by a portable

roentgenographic unit. This method is considerably easier than using the special reduction machine and a fluoroscope. The author has found that the patient is more comfortable when external skeletal fixation is used after the fracture has been reduced. Pins which are inserted prior to the manipulation pull painfully on the soft tissues during and after the reduction, and the fixation apparatus is poorly tolerated.

As a method of traction on the ward, vertical traction in the 90-90-90 position has a limited use in femur fractures which are compounded by wounds of the posterior thigh. It is not intended to take the place of conventional methods of traction, utilizing the Thomas-Pearson splint. The femur is suspended to the Balkan frame by a weight, suitably directed over pulleys to maintain the thigh perpendicular to the bed. Comfortable right-angle flexion of the knee is best obtained by a standard Pearson knee attachment,

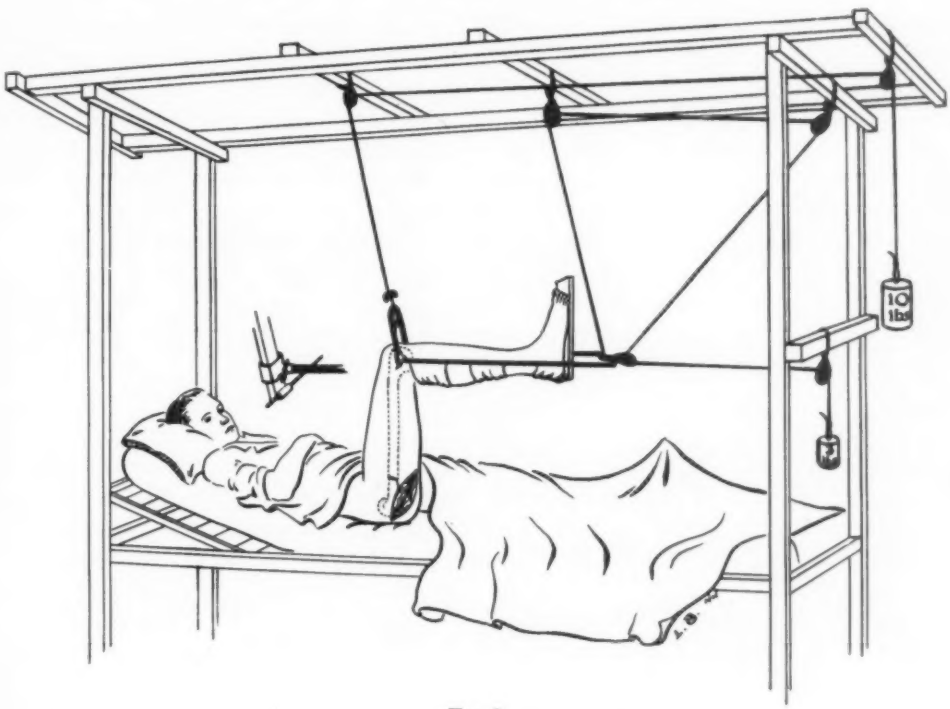

FIG. 3
Position of patient in 90–90–90 traction in bed.

fastened to the Kirschner wire bow. By a compound pull, a three-pound weight is sufficient to balance the leg in a position parallel to the bed. The foot is maintained at 90 degrees by a foot rest, which is added to the Pearson attachment (Fig. 3).

Soft-tissue care is most troublesome during the first few weeks of traction, and it is for this period that vertical traction offers advantages over the conventional methods. The method is simple and requires no special apparatus or skill. The patient is comfortable, and may use the bedpan without disturbing the alignment of the fracture. Dressings can easily be changed, as there is no interference by splint bars or slings. Wounds of the posterior thigh are as accessible as anterior wounds, and sutures and drains can be removed with ease. Snug compression dressings can be applied, and changed frequently, without displacing the fracture. The absence of a splint ring facilitates perineal care. Portable roentgenograms can be made in both planes without the annoying obstruction of opaque splint bars.

After a few weeks of vertical traction, the extremity should be brought down onto a conventional splint for the remaining period of traction. By this time the soft-tissue

wounds should be healed, if treated by secondary closure, or should have superficial granulations, if allowed to close spontaneously. Such disabilities as stretching of the quadriceps tendon or patellar ligament, contracture of the hamstrings, or fixation of the patella were encountered in several patients who were kept in the 90-90-90 position for periods of from eight to twelve weeks. No such disabilities were observed when this method was used for three or four weeks.

Restoration of length is easy by this method, and care must be exercised to prevent distraction, especially in patients with extensive loss of soft tissue or bone. In most instances, ten pounds of traction are sufficient; rarely will more than fifteen pounds be needed. Less weight is required to reduce fractures in the middle third of the femur than those at the trochanters.

Correct alignment by vertical traction can best be obtained in fractures involving the proximal third of the femur. Here the short proximal fragment is usually acutely flexed by the psoas pull, a position which relaxes the troublesome abductors and external rotators of the hip. The 90-90-90 traction has been employed with success in compound fractures of the neck of the femur. In fractures of the middle third of the shaft, it may be difficult to maintain alignment without coaptation splints, especially if there is considerable muscle destruction with consequent loss of the internal splinting effect of the intact muscle and fascial sleeve. Fractures of the distal third are better treated on the Thomas-Pearson splint, with or without combined traction of the tibia and femur.

Vertical traction, in the 90-90-90 position, for fractures of the femur should not be adopted to the exclusion of the conventional methods of traction; but when used in its proper place, it offers advantages in the management of difficult fracture problems, which are not afforded by other methods.

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RESECTION OF THE CLAVICLE IN VASCULAR SURGERY

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In the approach to the great vessels at the base of the neck, the clavicle frequently prevents adequate exposure and control of the vessels proximal and distal to the vascular lesion. The safety of vascular surgery in this region depends largely upon the accuracy with which isolation of these structures is accomplished. It has long been recognized that the removal of a portion of the clavicle will greatly increase the exposure obtained, but the problem of subsequent clavicular repair has led to many variations in wound closure. Following subperiosteal removal of the segment, it is a common practice to replace the excised bone, using some type of wire or metal for fixation. Deformities, non-union, and pain frequently follow such a procedure.

Forty-eight patients in whom the clavicle has been partially removed have been operated upon at Ashford General Hospital for aneurysm and arteriovenous fistula of the subclavian, axillary, carotid, and innominate vessels and their branches. In lesions of the base of the neck and the superior mediastinum, resection of the medial half of the clavicle, together with its sternal articulation, has been performed in order to increase the exposure. The subclavian and axillary vessels are approached by resection of only the central third of the bone.

The patients operated upon varied in age from nineteen to thirty-eight years. Thir-

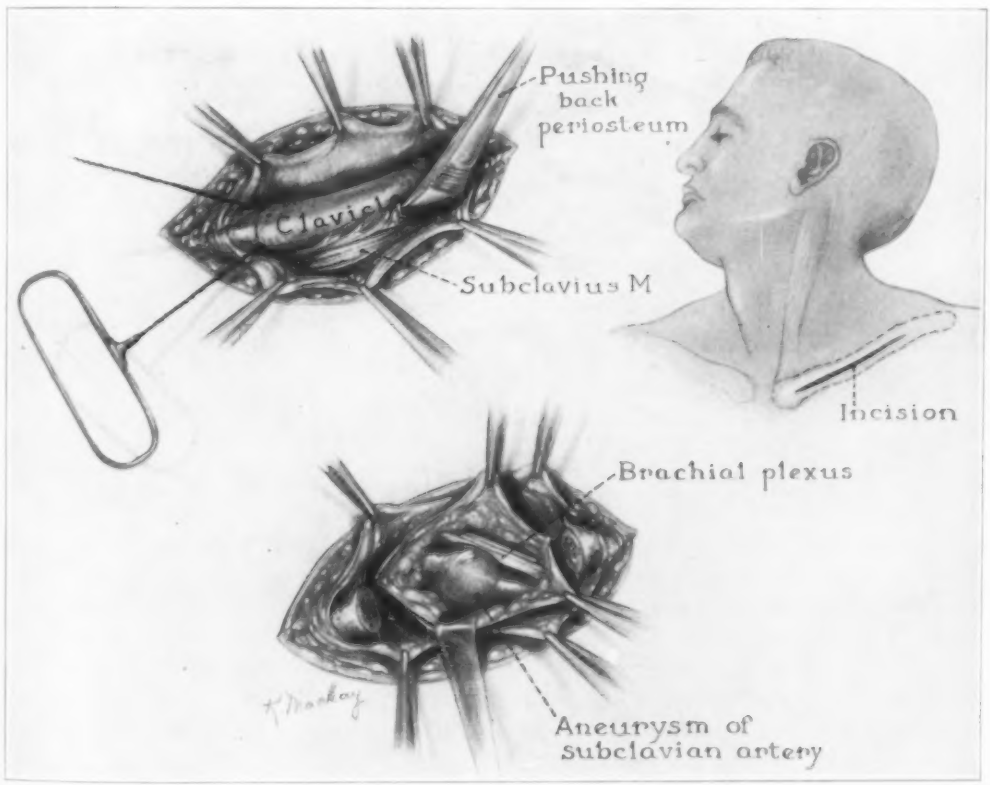

FIG. 1

Resection of clavicle for aneurysm of subclavian artery and associated injury to the brachial plexus.

FIG. 2

Resection of clavicle for subclavian aneurysm. Appearance of wound ten days after operation. No deformity.

FIG. 3

Resection of clavicle with extension of the incision upward for arteriovenous aneurysm of the internal carotid jugular vessels. Appearance three weeks after operation. No deformity.

FIG. 4

Resection of medial third of clavicle and extension of incision upward for excision of internal carotid jugular arteriovenous aneurysm. Appearance three weeks after operation. No deformity.

FIG. 5

Resection of clavicle and extension of incision outward and downward for excision of axillary arteriovenous aneurysm. Appearance ten days after operation. No deformity.

teen had associated nerve injuries, which were repaired at the same operation. The central portion of the clavicle was resected in thirty-four instances and the medial half, including the sternal articulation, was resected in fourteen cases. In eleven cases the vascular lesion was a false arterial aneurysm, in thirty-five cases it was an arteriovenous communication, and in two cases there was constricting scar tissue about the vessel. The vessels involved are shown in Table I.

TABLE I

VESSELS INVOLVED IN RESECTION OF THE CLAVICLES

	Number of Cases
Innominate	1
Subclavian	22
Axillary	14
Carotid	5
Vertebral	3
Transverse scapular	2
Transverse cervical	1
Total	48

TECHNIQUE

An incision is made over the most prominent portion of the clavicle to be resected and, if necessary, is extended along the course of the vessels (Figs. 1, 2, 3, and 4). Bleeding is reduced by incising the periosteum on the anterior surface of the bone away from the sites of muscular attachment. The periosteum strips freely, but the transverse scapular vessels run close to the posterior surface of the clavicle and are easily injured if the periosteum is torn. The clavicle itself frequently forms a portion of the arterial false sac;

its removal may be accompanied by profuse bleeding, which must be controlled by digital pressure at the site of the opening. The mobilized portion of the bone is then divided with a Gigli saw and discarded. If the sternal end is removed, the cartilage should be excised. A vertical incision beneath the sternal end will expose the innominate and carotid vessels, and the first portion of the subclavian vessel and its branches. A vertical incision through the central portion of the clavicular bed will expose the subclavian vessels and the brachial plexus. Division of the scalenus anterior muscle facilitates exposure of the first and second portions of the subclavian artery. Development of the interval between the pectoralis major and deltoid muscles, with the cephalic vein as a landmark and with division of the costocoracoid membrane, will greatly increase the exposure, permitting access to the axillary vessels (Fig. 5). Closure of the wound is effected in layers, repairing the periosteum with interrupted fine silk sutures. The excised segment of the clavicle is not replaced. The dressing is enforced with adhesive tape, leaving the arm and forearm free.

RESULTS

There is little postoperative discomfort associated with the procedure, and the patients become active without pain within two weeks. There is little external deformity, and less asymmetry than in instances in which the clavicle is replaced (Figs. 6 and 7). Slight shortening is occasionally noted. Although the regeneration of bone is slow, the area becomes firm within two weeks, with the shoulder girdle adequately fixed. Palpation of the area is deceptive at this time, as the absence of the bone cannot be detected. The patient usually returns to normal activity within six or eight weeks. There was no appreciable difference in the postoperative results in cases in which the articular portion was resected.

FIG. 6

Resection of inner half of clavicle and portion of sternum for innominate arteriovenous aneurysm. No deformity. Normal range of motion.

FIG. 7

Resection of left clavicle for excision of transverse scapular arteriovenous aneurysm. Appearance two months after operation. Superimposed pictures show range of motion.

Although the function of the clavicle is generally regarded as that of a fulcrum to provide better lateral motion of the arm, its occasional congenital absence is of little if any consequence. In many Carnivora, it is normally rudimentary. Surely it does not regenerate within two weeks after subperiosteal resection, although within that time the arm regains its functional activity. New bone can be palpated within a few weeks, but several months will elapse before it can be demonstrated by roentgenogram.

NOTE: Resection of the clavicle, as discussed in this paper, is concerned only with the approach to blood vessels. In this Hospital it has been employed in eighteen additional instances in operations upon the brachial plexus. In one other patient a portion of the clavicle was resected because of painful union of a fracture, with subsequent relief of pain and improvement in function of the arm.

TRANSVERSE SACRAL FOLDS *

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Since the introduction of continuous caudal analgaesia into the field of obstetrics by Edwards and Hingson, the topography of the sacrum has merited attention. In recent studies of the anatomical features and structural variations of the sacrum by Trotter and Letterman, ten sacra were encountered which presented bony configurations on the dorsal (or posterior) surface simulating a transverse fold, best marked within the limits of the articular sacral crests, and involving the sacral grooves and median crest.

This paper has as its purpose a detailed description and pictorial presentation of this variation, together with some comments upon its race, sex, and age incidence, accompanying skeletal changes, possible etiological factors, and probable clinical significance.

The original observations were made on 1,227 sacra, of which 553 were male and 674 were female. Of the bones studied, 881 form a part of the Terry Anatomical Collection, Washington University, and 346 are a part of the Todd Anatomical Collection, Western Reserve University. The preparation and methods of documentation of these collections were described by Cobb and by Terry, in 1932.

The following anatomical description of the dorsal surface of the typical sacrum was made by Terry in 1942: "The dorsal surface [facies dorsalis] is strongly convex and rough, giving origin to the powerful sacrospinalus muscle. The midline is occupied by the median sacral crest [crista sacralis media] representing the somewhat suppressed cranial four spinous processes. Of these the first is the largest, the second and third may be confluent, and the fourth is rudimentary. The bone on each side of the median sacral crest is slightly hollowed and is formed by the united laminae. . . . Lateral to the median sacral crest are the paired articular sacral crests [cristae sacrales articulares] representing the articular processes of the movable vertebrae. . . . Immediately lateral to the articular processes are the posterior sacral foramina [foramina sacralia posteriora] (f. s. dorsalia INA), four on each side; smaller than the anterior foramina, they give exit to the posterior primary divisions of the first four sacral nerves and branches of the lateral sacral arteries. . . ."

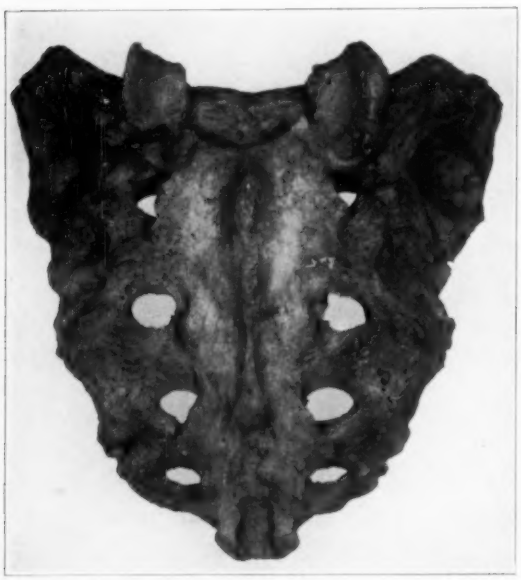

FIG. 1

W. U., No. 686. White female, seventy-eight years of age. Dorsal view of a typical sacrum.

The sacra which present the transverse folds are described individually, and the condition of each skeleton as a whole is noted. For comparison, the dorsum of a typical sacrum may be seen in Figure 1.

Skeleton W. U., No. 480, was of a white female, aged seventy-seven years. The sacrum presented a deep transverse fold at the level of the union of the laminae of the second and third segments (Fig. 2-A). The fold appeared as though the upper or cephalic portion of the dorsum of the bone had telescoped into the lower portion. It was sufficiently deep and depressed to have completely obliterated the lumen of the sacral canal at this level. The second pair of posterior foramina were markedly reduced in size

* Aided by a grant from the United States Public Health Service.

FIG. 2-A

Fig. 2-A: W. U., No. 480. Dorsal view.

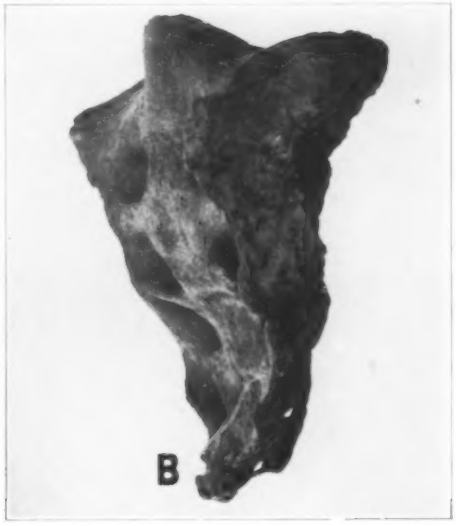

FIG. 2-B

Fig. 2-B: Oblique view of ventral surface.

and showed very irregular circumferences. The tuberosities of the bone were "wrinkled" and presented unusually deep depressions, or fossae. The ventral surface of this sacrum had a sudden concavity forward, beginning at the union of the bodies of the second and third vertebrae (Fig. 2-B). Among the movable vertebrae, marked reduction of the anterior vertical height of the bodies, accompanied by cupping of the superior and inferior surfaces, characterized the sixth, eighth, and twelfth thoracic vertebrae; cupping was also present in the third and fifth lumbar vertebrae. The skeleton in general was somewhat demineralized and porous in texture.

Skeleton W. U., No. 997, was of a white female, aged eighty-eight years. The fold on the dorsum of this sacrum (Fig. 3-A) was at the level of union of the second and third segments, but was much less marked than that of No. 480. It might be described as a transverse sulcus. The second posterior sacral foramina were somewhat reduced; their circumferences were smooth. The ventral surface of the first sacral vertebra and the lateral mass of the second sacral vertebra presented depressions in the sagittal plane (Fig. 3-B). Beginning at the level of the fourth thoracic vertebra, the remaining thoracic vertebrae and the lumbar vertebrae all showed diminution in the vertical height of the bodies, accompanied by cupping of both the superior and inferior surfaces. Both conditions were extreme in the seventh, eighth, and eleventh thoracic vertebrae, and in the third and fifth lumbar vertebrae. (The tenth thoracic and the first lumbar vertebrae were missing.) The centrum of the eighth thoracic vertebra presented a fold in the anterior and lateral parts of its circumference, lying in a transverse plane. There was an unhealed fracture of the neck of the left femur. The entire skeleton was exceedingly porous and demineralized.

FIG. 3-A

Fig. 3-A: W. U., No. 997. Dorsal view.

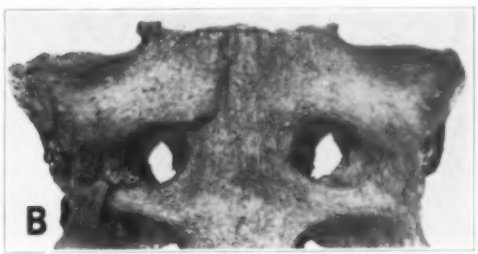

FIG. 3-B

Fig. 3-B: Ventral surface of first two segments.

FIG. 4
W. U., No. 1370. Dorsal view.

FIG. 5
W. R. U., No. 1451. Dorsal view.

Skeleton W. U., No. 1370, was of a white female, eighty years of age. The fold on the dorsum of this sacrum was found at the level of union of the laminae of the third and fourth vertebrae (Fig. 4). The third pair of posterior foramina were reduced in size; the right one was almost obliterated. The tuberosities showed "wrinkling", and the bone as a whole was very flat. The cervical and thoracic segments of this column, between the levels of the third cervical and the seventh thoracic vertebrae, presented lipping of the bodies (this has been described by Hrdlička as one of the natural processes of old age); the third and fourth cervical vertebrae were fused, as were also the fourth and fifth thoracic vertebrae. The left hip bone showed evidence of a healed fracture at approximately the mid-region of the inferior ramus of the ischium. Except for the skull, the skeleton was cinder-like in texture.

Skeleton W. R. U., No. 1451, was of a white female, seventy-five years of age. Two transverse folds were seen in the sacrum (Fig. 5). One lay at the level of union of the laminae of the second and third vertebrae; the second, which was more of a sulcus than a fold, occurred between the fourth and fifth sacral vertebrae. The second and fourth pairs of posterior sacral foramina were markedly reduced in size. The bone was very flat; the dorsal surface was actually concave forward at the level of the upper fold. The seventh cervical vertebra presented slight lipping. The last four thoracic vertebrae and all of the lumbar vertebrae showed compression of the vertical diameters of the bodies; the lumbar segment

FIG. 6
W. U., No. 1496R. Dorsal view.

FIG. 7
W. R. U., No. 1753. Dorsal view.

FIG. 8
W. R. U., No. 1754. Dorsal view.

FIG. 9
W. R. U., No. 2606. Dorsal view.

presented lipping, also. There was an unmended fracture of the neck of the left femur. The skeleton was exceedingly demineralized.

Skeleton W. U., No. 1496R, was of a white female, aged sixty-nine years. The dorsum of the sacrum presented a slight fold at a level between the laminae of the second and third segments (Fig. 6). This fold had the form of having had the upper part of the bone telescoped over the lower part. The second pair of foramina were reduced in size. The first coccygeal vertebra had become sacralized. The cervical spine showed lipping. The seventh, ninth, eleventh, and twelth thoracic vertebrae, and the first lumbar vertebra, showed marked reduction in general thickness of the bodies, together with an even greater diminution of the anterior heights. These bones also presented cupping on the superior and inferior surfaces of the centra. The cupped condition could be seen in each of the lumbar vertebrae. The left femur showed an unhealed fracture of the neck (with a Smith-Petersen nail maintaining the two fragments in place), and a second unhealed fracture at the level of the junction of the first and second fourths of the shaft. The left hip bone presented a healed fracture at the junction of the body of the pubis with its inferior ramus. The skeleton, including the skull, was extremely light and demineralized.

FIG. 10
W. R. U., No. 2773. Dorsal view.

FIG. 11
W. R. U., No. 3099. Dorsal view.

Skeleton W. R. U., No. 1753, was of a white female, eighty years of age. The sacrum had a transverse fold between the union of the second and third laminae (Fig. 7). The second posterior sacral foramina were reduced in size. There was an ovoid aperture on the right side, indicating a deficiency in the union of the first and second laminae. The cervical vertebrae showed marked lipping; this condition was slight in the thoracic region, except for the tenth and eleventh vertebrae, which were fused. Lipping was also slight in the lumbar region, but the bodies of the vertebrae of this segment were compressed, and there was cupping of the superior surfaces of the second, third, and fourth vertebrae. The skeleton was greatly demineralized, and had the cinder-like texture found in old age.

Skeleton W. R. U., No. 1754, was of a white female, eighty years of age. The sacrum was in poor condition; the right joint area and adjoining bone had been broken off and lost. Probably the fragile texture contributed to this accident during the skeletonization process. However, a sulcus was present at the level of the second laminae (Fig. 8). The second foramina, especially the one on the left, were reduced in size. The bone was markedly concave forward on its ventral surface. The movable vertebrae showed nothing of interest. The neck of the left femur had an unmended fracture. In general, the skeleton was fragile and demineralized.

Skeleton W. R. U., No. 2606, was of a white female, aged eighty years. The sacrum was composed of six segments, of which the first showed rather well-marked lumbar characteristics. The fold, which appeared slightly above the level of union of the second and third pairs of laminae, was accompanied by constricted foramina (Fig. 9). The fourth, fifth, and sixth cervical vertebrae had slight lipping, and the anterior margins of the bodies were somewhat compressed. The skeleton was extremely light and demineralized.

Skeleton W. R. U., No. 2773, was of a negro female, sixty-four years of age. The first coccygeal segment was fused to the sacrum. A transverse fold was present at a slightly higher level than the union of the second and third laminae (Fig. 10). The second posterior foramen on the left was reduced and the right one appeared to be enlarged; however, close inspection revealed that the margins had been broken away. The tuberosities were very much wrinkled. On the anterior surface, transverse furrows or sulci were present at the point of union of the lateral parts of the first and second vertebrae,—the usual site of broad grooves occupied by the anterior primary divisions of the first sacral nerves. The sixth to the twelfth thoracic vertebrae showed marked anterior lipping; the seventh, eighth, ninth, and tenth vertebrae were completely fused. The fourth and fifth lumbar vertebrae were fused by ossification of the ligamenta flava. There was evidence of anterior lipping on the fifth lumbar vertebra. The left humerus had been broken in the upper third of its shaft. In general, the skeleton was greatly demineralized, rarefied, and cinder-like in texture.

Skeleton W. R. U., No. 3099, was of a white female, forty-two years of age. The sacrum was composed of six segments, the first of which was the fifth lumbar vertebra. A fold was present at the union between the laminae of the first and second sacral vertebrae (Fig. 11). The first posterior sacral foramina were diminished. The tuberosities presented wrinkling. No unusual features were noted in the movable vertebrae. The skeleton was exceedingly light, demineralized, and cinder-like in texture.

COMMENT

The ten specimens which showed transverse sacral folds were all found in female skeletons. Of the 1,227 sacra studied, 553 were male. Thus, among the female sacra, 1.5 per cent. showed the condition; the occurrence was 3.9 per cent. in 233 white females and 0.2 per cent. in 440 negro females. It is therefore possible that race may be a significant factor. Age also plays an important part since, with one exception (W. R. U., No. 3099, aged forty-two), all specimens were from individuals sixty-four years of age or older. In the series examined by Trotter and Lanier, the ages ranged from fourteen through 101 years, with a fairly even distribution from the third through the eighth decades. There were 194 females who were sixty years of age or older, and 4.6 per cent. of this group presented a transverse fold.

Willis found congenital variations to be quite common in the lumbar and sacral regions of the vertebral column. The fact that all the folds occurred at or near the site of union of two contiguous vertebrae suggests that the folds may be congenital and result from an anomalous development of the segments. On the other hand, the fact that none of the folds were found in a young specimen is equally suggestive that the condition may develop during life. In an effort to find transverse folds in children, 200 roentgenograms of children up to fifteen years of age were examined. They are in the files at Shriners' Hospital, St. Louis, and include a large number which show congenital variations. At the Mallinckrodt Institute of Radiology, 125 roentgenograms of adult sacra were also exam-

ined. These included examples of spina bifida, malignancy, arthritis, and fracture, as well as normal sacra. Nothing resembling a transverse fold was found. No roentgenograms of healed sacral fractures were examined, however; only fresh fractures were included in this series.

Osteoporosis has been shown to be a constant finding in the skeletons described. Black, Ghormley, and Camp, in a comprehensive article on senile osteoporosis of the spinal column, called attention to the fact that the condition is seen approximately four times as often in women as in men. As osteoporosis progresses, the bony trabeculae decrease in number and they are no longer able to support the weight of the body; the vertebral bodies react to this by collapse, and fractures are common. In several of the specimens described in this report the transverse fold could be seen to continue laterally as a line, and on the anterior aspect it included the area lateral to the sacral foramina. However, the median area of the anterior aspect showed no defect. These folds might conceivably represent a buckle type of fracture, occurring in a bone previously weakened by osteoporosis.

Regardless of the etiology, it is possible that these defects may be clinically significant. Sarpyener has shown that sensory and motor changes can arise from congenital narrowing of the vertebral canal. It has also been stated by Bonnin that, following sacral fractures, compression of nerves exiting through the anterior sacral foramina may produce varying degrees of paralysis of the lower extremities. The foramina involved in these cases, however, are the posterior sacral foramina, through which pass the posterior primary divisions of the spinal nerves concerned. These nerves contain motor components which supply the lower autochthonous muscles of the back, and sensory components which, as the medial clunical nerves, supply the skin over the gluteal region. Following compression of these nerves, one might expect consequent sensory changes and slight atrophy of the muscles supplied. The muscle atrophy, however, would be so slight as to be unrecognized, and the sensory changes would very likely be obscured by the symptoms produced by the hypertrophic arthritis and osteoporosis present in these individuals. Case records of four of the individuals from whom these specimens came were available, but they were very brief and contributed no pertinent information.

NOTE: The authors wish to express their appreciation to Normand L. Hoerr, M.D., Professor of Anatomy, Western Reserve University, for the privilege of studying the Todd Anatomical Collection; and to Sherwood Moore, M.D., Director of the Mallinckrodt Institute of Radiology, for the privilege of studying the roentgenograms of adult sacra.

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SPASTIC FLAT-FOOT *

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Although the painful condition of the foot, usually diagnosed as "spastic flat-foot", "rigid flat-foot", "contracted flat-foot", or "spasmodic flat-foot", represents a definite clinical entity with sharply defined characteristics, most of the textbooks fail to give a clear description of its symptoms, etiology, and treatment.

REVIEW OF THE LITERATURE

Most investigators seem to believe that this condition is a form or a phase of flat-foot, which became irritated and inflamed as a result of faulty mechanics.

This view was expressed as early as 1883 by Lorenz, who considered "spastic flat-foot" the result of an instinctive, reflex fixation of the irritated, inflamed flat foot in the position in which it is the least painful. Lorenz quoted Roser, who compared the spastic flat foot with fixation of the femur in coxitis. Not every flat foot, according to Lorenz, develops to the phase of "contracted flat-foot". The irritative, inflammatory process not only occurs in the joints, but it must be assumed that traumatic periosteal irritation is also produced. Lorenz was convinced that a flat foot can never be converted into a well-arched foot; and it is even less possible to re-establish a normal shape in an old flat foot. His method of handling this condition was mainly preventive, being instituted before the flat foot became a spastic flat foot (*contracten Plattfuss*). Lorenz noted that the foot of the newborn child is always flat, and the arch develops with growth.

The author's experience has led him to the conclusion, advanced by Lorenz in 1883: "Flat-foot, therefore, may be looked upon as a result of absence of this process of growth and is due to arrest of its development".

Jones and Lovett, discussing flat-foot, state: "Peroneal spasm, as a rule, accompanies the more severe cases. The peroneal tendons will be found contracted and standing out under the skin, the foot is abducted and everted, and attempted correction is painful along the course of the peroneal muscles. . . . Spasm of the extensor digitorum is sometimes found in addition to that of the peronei." These investigators recommend peroneal tenotomy (devised by Jones), and "an alternative method of eliminating the spasm is to crush the musculo-cutaneous nerve" [17].

Whitman does not describe this condition as a separate ailment. He writes: "Limitation of motion is caused by the changes in structure in accommodation to functional use. These are first evident in muscles, then in the ligaments, and, finally, in the articular surfaces of the bones. Added to this underlying limitation of motion there is usually a certain degree of muscular spasm, which varies in grade with the local congestion, irritation, and inflammation of the joints and tissues."

Whitman defines the extreme deformity of rigid weak foot as one "in which the symptoms are disabling and in which the foot is fixed in the deformed position by muscular spasm and by secondary changes in the structure". He recommends forcible overcorrection of the deformity under anaesthesia and immobilization in a plaster cast, followed by physiotherapy and daily passive manipulations. He states: "Occasionally also in resistant cases division of the peroneal tendons may be advisable."

Dickson and Diveley, discussing the pathology of flat-foot, are no more explicit in describing their observations. They write: "If the causes responsible for pes planus continue active over a long period of time, prolonged irritation of the ligaments and joints of the foot may result in proliferative changes in these ligaments and joints, particularly if an arthritic diathesis is present. Whether a true arthritis develops or the changes in the foot joints are merely those of chronic irritation, the range of motion in these joints is reduced or even lost, and the foot becomes fixed in the position of deformity and a rigid

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pes planus results. With the foot fixed rigidly in pronation and eversion, the peroneal muscles contract and shorten, and so contribute to the rigidity of the foot, and provide an additional check to joint movement. . . ." "In the rigid type of flatfoot, the tendons of the peroneus longus and brevis will be short and contracted, the lateral mobility of the foot will be seriously limited, and it will be impossible to bring the foot into a position of correction."

The treatment recommended by Dickson and Diveley for rigid flat-foot is exactly the same as advised by Whitman: manipulation under anaesthesia, immobilization in a plaster cast, physiotherapy, and passive manipulations. "At times the peroneal tendon and the tendo achillis are so contracted that it is necessary to lengthen these structures by operation before complete correction of the valgus position of the foot is possible."

Lewin, discussing the pathological anatomy of the pronated foot, states: "The peroneal tendons are contracted because they are allowed to shorten." The following method of treatment, attributed to Freiberg, is outlined: In cases of spasm of mild degree, adhesive strapping is used and "should be continued until it is possible to bring the foot into supination". This is supplemented with "injection of a few drops of a 5 per cent novocain solution into the astragalo-navicular joint". "For cases in which peroneal spasm is too rigid to yield to these simpler methods", resection of peroneal tendons "with subcutaneous division of the tendon of the extensor communis digitorum muscles" is advised. "In cases of rigid flat-foot, forcible manipulation under anesthesia and the application of a corrective plaster cast are of great value. Occasionally, the peroneal tendons must be resected."

Weil does not agree with the prevailing conception of the reflex origin of muscle spasm in contracted flat-foot, caused by irritation of the subtalar joint subsequent to abnormal position of the bones. In two of his cases, he attempted to freeze the peroneal and tibial nerves above the ankle after these nerves had already given off their motor branches to the leg muscles, thus interrupting chiefly the sensory branches to the ankle and foot joints. The muscle contraction disappeared during the operation while the patients were under anaesthesia, but the painful spastic flat-foot recurred after the operation in both cases. Hence came Weil's theory of "proprioceptive reflex", which he believes is caused by changes in the muscles themselves, but not from irritated foot joints. Weil's two cases are not at all convincing. He does admit in his conclusion that the whole problem is not clear, since only a few patients with flat-foot ever develop spastic flat-foot. Likewise, it is not clear to him why spasm does not occur also in pes varus. The latter question seems to be an important one and will be discussed later.

Haberler and Winkler also refuse to accept the theory of formation of spastic flat-foot from a flaccid flat foot as a result of faulty mechanics, caused by inward and downward displacement of the talus against the calcaneus, the thrust of the talar head producing strain of the medial ligaments and irritation of the talonavicular joint, which in its turn induces a cramplike reflex muscle spasm. They quote Lorenz's attempt [12] to prove experimentally the theory of reflex spasticity by relieving the muscle spasm, after injecting novocaine into the talonavicular joint in cases of spastic flat-foot. This has been looked upon as interruption of the reflex arc.

According to Haberler and Winkler, this theory of reflex spastic flat-foot has been almost unanimously accepted, although various locations of the irritation causing the spasm have been considered by different writers.

Payr claimed the irritation to be mainly of the posterior chamber of the subtalar joint; Hoffa localized it in the talonavicular ligament, while Hohmann and also Port held that the irritation of the synovial lining and of the periosteum of the Chopart joint was responsible for the initiation of the reflex chain leading to the spasm.

Haberler and Winkler bring out the point that the spasticity occurs almost exclusively in the pronators (chiefly the peroneal muscles). They assume that the medial structures of the talonavicular joint must be the ones that are mainly irritated by the

medial and downward thrust of the talar head in a flat foot. Consequently, they would expect the supinators of the foot to become spastic and not the pronators. Therefore, they cannot agree with the reflex origin of the muscle spasm in spastic flat-foot. In 28 per cent. of their cases, Haberler and Winkler found evidence of psychic and somatic "degenerative changes" with signs of disturbance of the pyramidal tract. Hyperflexion was almost always noted in their patients, and out of a total of forty-two cases of idiopathic spastic flat-foot, positive Babinski reflex or Oppenheim's sign was obtained in ten cases. Haberler and Winkler conclude that spastic flat-foot only rarely occurs from flaccid flat-foot, and explain the origin of the "idiopathic muscle-bound flat foot" as a lesion of the central nervous system.

Although the work of these investigators gives the impression of being quite thorough and complete, their neurogenic theory seems to be too artificial and speculative, and has not been corroborated by other observers.

Little can be found on the subject in Hohmann's book on the foot. He devotes no separate discussion to spastic flat-foot and essentially agrees with the accepted theory of causation of the contracted flat foot. He brings out the fact that the tibialis anterior may become converted from a supinator into a pronator of the foot, as the result of marked abduction of the forefoot in flat feet (Fig. 3-A). In such cases the tibialis anterior and the peronei may be found spastically contracted, and may cause a dorsiflexion contracture of the foot combined with valgus. Hohmann advises against forceful manipulations in rigid flat-foot and considers interruption of the peroneal nerve an irrational procedure, since "the cause of the pronator's spasm lies not in the muscles themselves, but in the process of deformation of the flat foot".

Malkin defines spasmodic flat-foot as "a condition in which the foot, without evidence of a bony lesion, is held in a valgus position by spasm of the peronei".

According to Fick, the invertors of the normal foot are stronger than the evertors. Therefore, if there were any lesion of the subtalar or midtarsal joint, the foot must be expected to assume an inverted (varus) position as a result of a protective spasm of all its muscles.

Testing the relative strength of the invertors and evertors, Malkin found that in a group of patients undergoing treatment for flat-foot, the above normal relation was reversed, the evertors becoming stronger. Therefore, Malkin concludes that in flat-foot the invertors become relatively weaker and, if "there were a lesion of the subastragaloid and midtarsal joints, protective spasm might be expected to hold the feet not in inversion, but in eversion".

In a discussion of Malkin's paper, Brockman reported disappointing results in his cases, and pointed out that: "In those in which the peronei had been divided, no permanent benefit resulted compared with the others."

Trethowan, also discussing Malkin's paper, stressed the view that "spasmodic flat-foot had nothing really to do with flat-foot". He blamed infectious astragaloscaphoid and subastragaloid arthritis for causing spastic flat-foot, and called it "tonsil flat-foot". Except for early cases, he considered the condition incurable. He abandoned manipulations and used only rest and support for the feet.

Todd, in a very frank paper, said: ". . . the most I can hope to do is to give a concise summary of the present state of our ignorance". After reviewing the literature on the subject, the writer shares entirely Todd's disappointment, which he expressed as follows: "Not much is to be gained by a perusal of recent surgical literature on this subject." The textbooks "merely present a vague unhelpful description of what they call 'rigid flat-foot' ".

Likewise, Todd's dissatisfaction with the present-day methods of treatment so clearly voices the author's feelings that it is best given verbatim: "In acute spasmodic valgus, therefore, we must not treat the spasm only: that is not the disease, but the result of the

disease. For that reason I regard tenotomy and excision of the peroneal tendons as being based on an entire misconception. And everyone knows that, as a matter of fact, these operations are often unsuccessful, and prone to be followed by reappearance of the pain and deformity. Seeing that the primary cause of the condition has been left unaffected, this is not surprising. Paralysing the peroneal nerve or its musculo-cutaneous division with novocain or alcohol, or crushing it or freezing it, abolishes the spasm for a time but does not remove its cause."

Todd believes that treatment by manipulations and immobilization in varus is not rational and should not be used. He discusses the possibility of eversion of the foot as being the position "of rest or relaxation, in which the joint surfaces on the inner border of the foot are held apart and the joints themselves are in their position of greatest capacity". Therefore, he prefers to immobilize the foot without correction of valgus, which might be physiological in this ailment.

Thus the reflex origin of spastic flat-foot has been recognized for more than half a century, and has been described in all recent textbooks. However, no clear understanding of the exact location and the mechanics of the irritating moment has as yet been reached, as can be judged from the variable interpretations of the origin of the irritation, given by different investigators. In spite of this rather unsettled state in regard to the etiology of the condition, most of the therapeutic procedures seem to be quite uniformly aimed at interruption of the reflex arc. Manipulations under anaesthesia and immobilization in a plaster cast with correction of the valgus deformity, followed by repeated manipulations and physiotherapy, still remain the up-to-date standard methods of conservative treatment.

Resection of peroneal tendons[8], intramuscular infiltration of peroneal muscles with novocaine, or induction of peroneal nerve palsy by freezing the nerve, intraneural injections of novocaine or alcohol, operative crushing of the nerve[17], or by means of a special brace causing pressure and crushing of the peroneal nerve[10] have been advocated as more radical procedures by different writers. However, those who followed their cases long enough and well enough had to admit not only their frequent failures to relieve the original ailment, but also the harmful complications occasionally produced by too radical and not quite sound surgery (for instance, the production of a lasting peroneal paralysis in one of Lilienfeld's cases).

Summarizing our review of the literature, we note that there are certain clinical features which have been agreed upon by all writers on this subject, while other characteristics of the spastic flat-foot have been described only by a few and were variably interpreted by them.

The following clinical features of the so-called spastic flat-foot are unanimously accepted by all observers:

1. It is a painful condition of the foot and ankle, associated with spasm always limited to the pronators (evertors) group. Chiefly the peroneal muscles, sometimes the long extensor of the toes, occasionally also the anterior tibial muscles are contracted, all acting as pronators.
2. Trauma or occupational strain seems to be recorded in an appreciable number of cases.
3. The onset of the condition has been noted most frequently during adolescence.
4. Only a relatively small percentage of cases of spastic flat-foot were noted, in proportion to the very much larger number of flaccid flat feet seen in clinics.

The following clinical characteristics have been variably interpreted:

1. Most of the writers, as the name "spastic flat-foot" itself implies, find evidence of pes planus in addition to valgus position of the foot.
2. On the other hand, a few other observers note a definitely normal or even exaggerated longitudinal arch (pes cavus), with the foot being held in valgus position by the spasm of the evertors.

3. The majority of writers consider the spastic flat-foot as a phase of flaccid flat-foot; a few refute any connection between flaccid and spastic flat-foot.

4. The pain and tenderness have been noted by the majority of investigators on the lateral aspect of the foot (calcaneocuboid joint, subtalar joint, sinus tarsi). A few observers localized it also over the medial aspect of the foot, mainly at the talonavicular joint.

5. Some observers consider the irritation of the talonavicular or calcaneocuboid, or subtalar (posterior chamber) joint to be due to static and mechanical distortions in flat-foot, being careful to differentiate the "idiopathic spastic flat-foot" from an arthritic one. Others also include in their series the arthritic cases and consider infectious arthritis of these joints as a primary cause of the whole condition (Trethowan's "tonsil flat-foot").

ANATOMY AND MECHANICS OF THE SUBTALAR JOINT

The most important question is why the pronators of the foot are the only muscles which have consistently shown an exclusive tendency to become "spastic".

Why has a similar spasticity never been noted in the supinators group?

Why has muscle spasticity never been associated with the varus (inversion) deformity of the foot?

The answers to these questions and clarification of the entire problem of the so-called spastic flat-foot may be found in the rather complicated anatomy and even more complicated mechanics of the subtalar joint.

The subtalar joint, often called the lower ankle joint or articulus talotarsalis, is a complex articulation between the talus (above) and the calcaneus and the navicular (below). An important structure of the subtalar joint is the interosseous talocalcaneal ligament. The fibers of the ligament run in an almost vertical direction, attaching themselves to the roof and the floor of the tarsal canal (sinus tarsi). The latter is formed by the adjacent deep grooves on the lower surface of the talus (sulcus tali) and the upper surface of the calcaneus, the sulcus calcanei (Figs. 1-A, 1-B, and 2).

The tarsal canal (sinus tarsi) runs obliquely forward and laterally; it is funnel-shaped, being wider laterally. The interosseous talocalcaneal ligament, filling the tarsal canal, likewise runs obliquely forward and laterally across the long axis of the foot (Figs. 1-A, 1-B, and 2). Thus this ligament forms a transverse vertical partition, dividing the subtalar joint into two completely separate chambers: the posterior chamber or articulus talocalcanea, and the anterior chamber or articulus talocalcaneonavicularis (Figs. 1-A and 2). Although anatomically these two articulations are entirely separate, functionally they represent one inseparable unit, since they can move only together and only against the same axis of motion (Figs. 1-A, 1-B, and 3-A). In this respect they can be roughly compared with two hinges of a door, which, although separate, yet always move together.

The motions of the subtalar joint consist mainly of supination (inversion) and pronation (eversion). In addition, supination is combined with some adduction and plantar flexion, while slight abduction and dorsiflexion occur simultaneously with pronation of the foot in the subtalar joint. The axis of motion of the subtalar joint runs slightly obliquely from the dorsomedial surface of the neck of the talus posteriorly, downward, and lateralward, emerging through the lateral posterior surface of the calcaneus (Figs. 2 and 3-A).

The subtalar joint possesses an unusual stability. Dislocation in this joint unassociated with a fracture is very uncommon. This is due mainly to two factors:

1. The alternating shape of the articular facets which are of ball-and-socket type, in both the anterior (talocalcaneonavicular) and the posterior (talocalcaneal) components of the subtalar joint (Figs. 1-A and 2). The upper articular surface of the talocalcaneal joint, supplied by the posterior articular facet of the talus, is concave; while below, the

corresponding posterior facet of the calcaneus is convex. The reverse relation exists anteriorly in the talocalcaneonavicular joint. Here the lower articular surfaces (calcaneus and navicular) are concave, while the upper articular surface (head of the talus) is convex (Figs. 1-A and 2).

2. The interosseous talocalcaneal ligament, firmly binding together the talus and the calcaneus.

FIG. 1-A

FIG. 1-B

FIG. 2

Fig. 1-A: Left foot viewed from fibular side and also slightly from above. Talus removed, showing the subtalar joint divided almost transversely by interosseous talocalcaneal ligament into two completely separate chambers: the anterior chamber, articulatio talocalcaneonavicularis and the posterior chamber, articulatio talocalcanea. The wooden applicators inserted through the talus and the calcaneus represent the axis of motion of the subtalar joint. Note that the interosseous talocalcaneal ligament is stretched between the sulcus calcanei (below) and the sulcus tali (above), both of these sulci forming the tarsal canal (sinus tarsi). Note also the alternating shape of the articular facets of the anterior and posterior chambers. In the anterior chamber, the head of the talus is ball-shaped and the navicular with the anterior and the middle facets of the calcaneus form the socket; in the posterior chamber the reverse relations are present, the talus is concave, and the calcaneus is convex.

Fig. 1-B: Fibular view of the same foot with the talus replaced. Note that the interosseous talocalcaneal ligament is most accessible to palpation over the fibular side at the sinus tarsi. *X* denotes the interosseus talocalcaneal ligament. Arrows show the pars calcaneonavicularis and pars calcaneocuboidea ligamenti bifurcati.

Fig. 2: The anterior and posterior chambers of the subtalar joint (left foot) viewed from above after removal at the talus. Wooden applicator inserted through the calcaneus represents the axis of subtalar joint motion which crosses the interosseous talocalcaneal ligament (*X*) under right angle, as shown by a toothpick inserted into this ligament from the fibular side. This ligament acts as a partition between the anterior and the posterior chambers of the subtalar joint. The tarsal canal, in which the interosseous talocalcaneal ligament stretches itself, is funnel-shaped, being wider on the fibular side and tapering toward the tibial side just behind the sustentaculum tali. The tarsal canal and also the ligament run obliquely anteriorly and fibulaward, forming an obtuse angle with the longitudinal axis of the foot (running along the second metatarsal).

A. Navicular facet for the head of the talus.
B. Anterior facet of calcaneus.
C. Middle facet of calcaneus over sustentaculum tali.
D. Plantar calcaneonavicular ligament, forming the floor of the anterior chamber of the subtalar joint.
E. Posterior facet of calcaneus (accidentally fractured).

3. Tendons and other ligaments stretching themselves over the subtalar joint.

Figure 3-B illustrates the ligamentous apparatus of the ankle. The head and the neck of the talus have been removed in order to expose the interosseus talocalcaneal ligament and show its relation to the axis of motion of the subtalar joint. It is apparent that the interosseous talocalcaneal ligament becomes tense on supination (inversion) and is relaxed on pronation (eversion), since this ligament is located entirely on the fibular side of the axis of motion. This point is further brought out on Figures 3-D and 3-E, showing the same specimen with the foot held in extreme inversion (Fig. 3-D) and in complete eversion (Fig. 3-E).

These anatomical considerations have furnished us with a definitely established fact in the mechanics of the subtalar joint,—namely, that pronation (eversion) of the foot removes the tension from the interosseous talocalcaneal ligament; in other words, the position of greatest relaxation in the subtalar joint is that of complete pronation (eversion), with the heel held in valgus.

This fact seems to give adequate explanation of the questions enumerated, which thus far have remained unanswered or have been variably interpreted by previous investi-

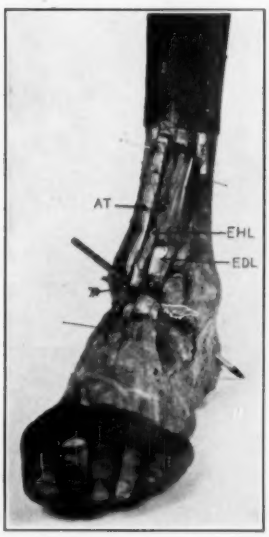

FIG. 3-A

FIG. 3-B

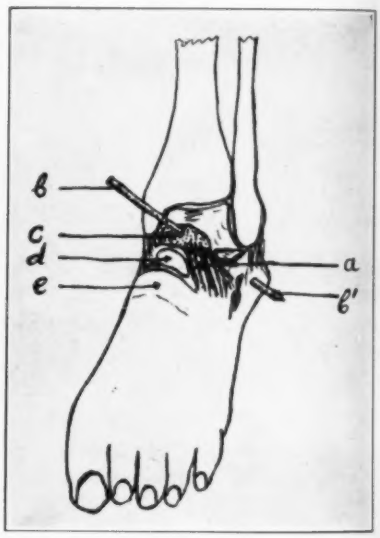

FIG. 3-C

Fig. 3-A: Left ankle and foot with nail representing axis of the subtalar-joint motion. This axis runs from the tibial side, from anteriorly and above toward the fibular side, posteriorly and downward, and does not correspond with the longitudinal axis of the foot (Fig. 2). Note that the axis of subtalar-joint motion passes right through the anterior tibial tendon (*AT*), spit longitudinally over the nail at small arrow. Therefore, in the neutral position of the subtalar joint the anterior tibial is a pure dorsiflexor of the foot, possessing no everting or inverting component. With the foot in inversion (supination), the anterior tibial tendon slips slightly tibiaward to the axis of the subtalar-joint motion; therefore, this muscle also becomes a slight invertor of the foot. When the foot is in eversion (pronation), the anterior tibial tendon slips fibulaward to the axis and consequently becomes a slight evertor of the foot. The extensor hallucis longus (*EHL*) and even more so, the extensor digitorum longus (*EDL*) run fibulaward to the axis of subtalar-joint motion, and therefore act as evertors (pronators) assisting the peroneals.

Fig. 3-B: Same foot, held in neutral position. The talocrural joint is exposed. The head and the neck of the talus have been removed, exposing the anterior chamber of the subtalar joint. Two toothpicks have been inserted into the interosseous talocalcaneal ligament. Note that this ligament is located fibulaward to the axis of the subtalar-joint motion (represented by the nail) and the main part of the ligament is quite a distance away from the axis.

Fig. 3-C: Shows schematically the details of Fig. 3-B.

a. Interosseous talocalcaneal ligament (the toothpicks are not shown).
bb'. Axis of subtalar-joint motion.
c. Rough bone surface of the talar neck, after removal of its head.
d. Floor of the anterior chamber of the subtalar joint.
e. Navicular.

FIG. 3-D

The same specimen with the foot in extreme inversion (supination). Note the wide separation of the toothpicks, proving that the interosseous talocalcaneal ligament becomes tense on inversion.

FIG. 3-E

Demonstrates complete relaxation of the interosseous talocalcaneal ligament on extreme eversion (pronation), the two toothpicks becoming closely approximated and parallel to each other.

gators. It certainly appears to provide a logical explanation for the exclusive tendency of the pronators to become spastic. Likewise, the tenderness over the sinus tarsi (the most accessible region of the interosseous talocalcaneal ligament) and over the subtalar joint itself can now be understood (Fig. 1-B).

DISCUSSION

Thus we may assume that any lesion of the interosseous talocalcaneal ligament, whether of traumatic or inflammatory origin, may produce the symptom complex of so-called spastic flat-foot. The interosseous talocalcaneal ligament is really a part of the subtalar joint, just as the two crucial ligaments are part of the knee joint; consequently, any lesion of the interosseous talocalcaneal ligament, with or without involvement of the entire subtalar joint, may bring about a typical clinical picture of pronators' spasm.

It should be mentioned in passing that a large number of cases observed by the writer not only failed to show any evidence of flattening of the longitudinal arch, but occasionally presented a definite cavus deformity. This was also noted by Haberler and Winkler.

It is true that in a few cases of flat-foot, spasticity may develop, but the percentage is very small, as has been pointed out by several other writers. It is possible that the percentage of feet with a normal arch, in which the spasticity syndrome develops, is just as great as that of flat feet which become spastic. The valgus position of the foot is misleading, and often is misinterpreted as flat-foot, although the longitudinal arch is normal or even exaggerated. Hence the term "spastic flat-foot" seems to be a misnomer and inappropriate, because more often than not there is no flat-foot.

"Spastic subtalar lesion" or "subtalar arthritis with spasm of the pronators" would seem to be better designations.

Spastic subtalar lesion is a symptom complex which obviously may result from various etiological conditions. First will be discussed the cases which have been classified by

some writers as "idiopathic spastic flat-foot". The typical symptoms seemed to develop in these patients spontaneously without any definite etiology of the condition. These cases may be divided into three groups, according to the extent and gravity of the pathological changes.

To the first group belong early cases of adolescent patients with no history of previous episodes. As has already been stated, the feet may be normally shaped (no flat-foot). History of trauma or of an occupational strain can be obtained in a majority of these cases. In sleep or if the patient is given local or general anaesthesia, the spasm of the pronators is entirely relieved. Infrequently, after mere rest in bed for a few days, all the symptoms may disappear. Early diagnosis and complete bed rest, followed by guarded activities and watchful observation, may prevent any further recurrences. Well-fitted metal foot plates and shoes may be helpful.

To the second group belong more advanced cases, with apparently fibrous periarticular changes, since there is absence of subtalar mobility even under general anaesthesia when the spasm of the pronators is completely eliminated. History of previous attacks of pain and spasticity may be obtained in some of these cases. The roentgenograms of the foot fail to show any bone changes. This group presents a more serious therapeutic problem. If rest treatment as suggested for the first group is not successful, sometimes gentle breaking of fibrous tissues by manipulation of the subtalar joint under general anaesthesia, followed by prolonged rest with physiotherapy and immediate active and passive exercises, may relieve the pain and spasm and even enable the patient to resume his work. Post-operative immobilization in plaster should not be employed, since it may bring about the recurrence of fibrous changes. It is doubtful, however, that complete restoration of subtalar mobility will be obtained in the majority of these cases. Recurrence of episodes of pain and spasm of the pronators may be anticipated, especially after overwork. Metal foot plates are helpful, even if the longitudinal arch is normal. Change of occupation to less strenuous work should be given serious consideration.

The third group includes inveterate cases, often patients with a history of several acute attacks and occasional pain and stiffness after overuse of the foot during the quiescent stage. Roentgenograms in these cases show more or less advanced productive osteo-arthritic changes, mostly over the adjacent surfaces of the talus and the navicular and often over the talocalcaneal and calcaneocuboid joints. During the periods of acute exacerbation the pronators become spastically contracted, the foot is painful, and there is periarticular subtalar tenderness most frequently over the sinus tarsi laterally, just in front of the lateral malleolus, sometimes also medially around the sustentaculum tali and just posterior to it (Fig. 2). Occasionally there is tenderness around the talonavicular joint. The heel is held in valgus, and any attempt at passive inversion produces pain. After rest, the spasm of the pronators may disappear, and acute pain and tenderness may be relieved, but the heel may still remain in valgus, and there will be considerable or even complete loss of subtalar mobility. Attempts at inversion of the heel still may be slightly painful, and some tenderness may be obtainable even during the apparently quiescent stage. Obviously therapy in this type of foot is rather limited, and should be directed toward prevention of acute episodes and alleviation of pain during the quiescent stage, in order to enable the patient to do some work, preferably without putting any excessive strain on his feet.

There has been a great deal of prejudice against the use of metal plates in this type of foot with its tarsal joints "rigid" because of secondary osteo-arthritic changes. It has been stated often that, in a "rigid" foot, rigid metal plates are contra-indicated, since the patient will not be able to wear them. Exactly the reverse conclusions seem to be justified from the author's experience.

Well-fitted plain metal plates (Schaffer's type) have been found extremely useful in these patients. It must be emphasized, however, that meticulous care should be exercised

in taking a cast (plaster boot) for these plates. While a foot with movable joints may sometimes adapt itself to an imperfectly fitted plate, a "rigid foot" requires a perfect fit of the plate to the foot. That may be the reason that many of these patients have discarded plates which they have been unable to wear, and yet frequently obtain a great deal of comfort when given a pair of well-fitted rigid metal plates, and often are actually unable to walk without them.

The author has been using exclusively rigid metal plates, since the non-rigid type, as a rule, failed to bring adequate relief. Evidently, only a rigid metal foot plate can provide enough bracing for the osteo-arthritic tarsal joints, just as only a rigid brace can adequately immobilize an osteo-arthritic knee.

In a very few obstinate cases with persistent disability, one may consider fusion of the entire subtalar joint, possibly combined with calcaneocuboid fusion. The writer is opposed to any extensive wedge resections of these joints, and prefers merely a shaving off of the articular cartilage without distorting the configuration of the joint surfaces. The cartilage can also be shaved off from the talar head and the navicular bone without resection of the talar head. The heel should be immobilized in a neutral position. Although some relief may be anticipated after this operation, the foot is far from being perfect and, therefore, the operation should be considered only reluctantly as a last resort in obstinate cases. As a rule, conservative methods patiently adhered to will bring enough relief and in the long run are better than the operation.

The symptoms of spastic subtalar lesion may develop in cases of rheumatoid arthritis. The inflamed subtalar joint is held in pronation in order to secure complete relaxation of the interosseous talocalcaneal ligament. Fibrous changes and often osteo-arthritic manifestations with limitation of subtalar mobility are the usual late results in these cases. The therapy in this type of case is essentially the same as in the idiopathic group. Prevention of valgus deformity by immobilization of the foot in neutral position should be considered before the onset of ankylosing changes. For obvious reasons, cases of fracture of the tarsal bones penetrating into the subtalar joint with lesion of the interosseous talocalcaneal ligament may also present the spastic symptom complex.

All the above considerations seem to furnish reasonable proof that any lesion of the interosseous talocalcaneal ligament may lead to a secondary protective spasm of the pronator muscles, in order to ensure complete relaxation of this ligament. There is no justification for the assumption that the spasticity is a result of primary changes in the pronator muscles [21] or is due to a lesion of the pyramidal tract[5]. Consequently, any operations designed to eliminate the action of the pronator muscles, such as resection of their tendons or induction of their palsy by any methods, should be strongly condemned as unsound, useless, and often harmful, since they are aimed to relieve the consequence without removing the cause of the condition.

No one would consider tenotomy of the hamstrings or crushing of the sciatic nerve, in order to relieve the protective flexion of the knee due to a lesion of its crucial or collateral ligaments. Yet a somewhat similar operative approach is still a standard procedure in the treatment of the so-called spastic flat-foot, and is recommended in textbooks.

It is the hope of the writer that he has given a logical explanation of the mechanics of the condition, now labeled "spastic flat-foot" and has pointed out the irrationality of standard surgical procedures employed in its treatment.

SUMMARY AND CONCLUSIONS

1. A review of the literature on the so-called "spastic flat-foot" shows variable, often contradictory, theories concerning its etiology and treatment.

2. The prevailing conception is that it is a reflectory spasticity of the pronators, which develops in a flaccid flat foot as a result of irritation of the tarsal joints, attributed to faulty statics and mechanics.

3. No satisfactory explanation for the fact that the spasticity is always limited exclusively to the pronators can be found in the literature, although various theories have been advanced.

4. The accepted standard treatment of the so-called spastic flat-foot has been rest, immobilization, physiotherapy, manipulations, resection of peroneal tendons, or even induction of palsy of the pronators by interruption of conductivity of the peroneal nerve by means of injections or crushing of the nerve.

5. A review of the anatomy and mechanics of the subtalar joint shows that the interosseous talocalcaneal ligament is relaxed in pronation, and becomes tense in supination of the foot.

6. The author's theory of the cause of so-called spastic flat-foot as a lesion of the interosseous talocalcaneal ligament or of the subtalar joint with reflex spasm of the pronators to produce relaxation of the above ligament is given.

7. The syndrome of spasticity of the pronators is not peculiar to flat-foot, but is often observed in normal feet or even in cases of cavus. Therefore, the terms, "spastic subtalar lesion" or "subtalar arthritis with spasm of the pronators" are offered as more appropriate designations than "spastic flat-foot".

8. A classification of cases with the method of treatment employed by the author is described.

9. The lesion of interosseous talocalcaneal ligament is the primary cause, and spasm of the pronators is the consequence. Therefore, any operations designed to eliminate the action of the pronator muscles (tenotomy or interruption of peroneal nerve) are strongly condemned as being unsound, futile, and often harmful.

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BACTERIOLOGICAL EXAMINATION OF THE GASTRIC CONTENTS IN THE DIAGNOSIS AND MANAGEMENT OF TUBERCULOSIS OF THE BONES AND JOINTS

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A substantial percentage of patients with active pulmonary tuberculosis, particularly infants and young children, do not expectorate, and consequently no sputum is available for bacteriological examination. The fasting gastric contents of more than 2,000 patients with pulmonary tuberculosis have therefore been examined for the presence of tubercle bacilli. In this group of cases the procedure has served as an indispensable criterion for the identification of active disease, and has been carried out either at the time of the diagnostic survey of the patient or during the course of treatment by bed rest or by pulmonary collapse.

Since 1898, when Meunier first advocated this diagnostic method, a number of publications have confirmed its usefulness. Most of the available reports, however, deal with its applicability in parenchymal pulmonary tuberculosis and in tuberculosis of the hilar lymph nodes. In patients with parenchymal pulmonary tuberculosis who do not expectorate or who have negative sputum, tubercle bacilli were found in the gastric contents in 60 per cent. of the cases of Gad, in 55 per cent. of Gullbring and Levin's cases, and in about 20 per cent. of the cases of Ulmar and Ornstein. In children with pulmonary tuberculosis (parenchymal or hilar), Opitz found tubercle bacilli in the gastric contents in 93 per cent., Boer in 73 per cent., and Langer in 40 per cent., as quoted by Dietzel.

These results suggested the possibility that examination of the fasting gastric contents might be of value in the diagnosis of patients suspected of having tuberculosis of the bones or joints. While early recognition of these cases is of the utmost importance from the standpoint of therapy, the diagnosis may be difficult in many instances. The well-known symptoms and signs are not pathognomonic. Milgram questioned the conception that these tuberculous lesions have an insidious onset. He found that out of 142 verified cases of osseous tuberculosis, the onset was sudden in 29.5 per cent., with severe pain in 26.7 per cent.; and that in 37 per cent. the results of roentgenographic examination were either of no help or were misleading. Much confusion arises from the fact that some of the roentgenographic findings seen in tuberculosis, such as synovitis, periarticular swelling, and bone atrophy, are often found in non-tuberculous arthritides. Osteosclerosis and osteophytic growth are more common in tuberculous lesions than is realized. Diagnostic difficulties may be encountered in tuberculosis of the rib, the sternum, and the sacrum, where the disease is not manifest until extensive destruction has taken place. On the other hand, tuberculous arthritis may be present without destruction of the bone and with entirely negative roentgenographic findings.

Such laboratory studies as the tuberculin test, the hemogram, and the sedimentation test are of limited diagnostic value. According to Seddon, biopsy of the inguinal lymph nodes in tuberculosis of the knee joint is worth while in that a positive result gives confirmatory evidence of the disease. Conclusive proof of the tuberculous nature of an arthritis may be gained by culture or by guinea-pig inoculation of the material obtained by aspiration of the joint, by punch biopsy, or by histological and bacteriological examinations at the time of operation.

During the past seven years the authors have studied twenty-two cases of tuberculosis of the bone, in which an attempt was made to corroborate the clinical diagnosis by bacteriological examination of the fasting gastric contents. Securing gastric specimens for

this purpose is a simple procedure that can be done by the physician, by a trained attendant, or by a laboratory technician. It is preferable to aspirate the gastric contents rather than to wash out the stomach. Aspirations are done on five successive mornings, as soon after rising as feasible, so as to avoid the possible spontaneous evacuation of the stomach contents. In Poulsen and Andersen's investigation of 199 tuberculous children, tubercle bacilli were recovered from the gastric contents in 77 per cent. on the first examination, in 96 per cent. after the second examination, and in 100 per cent. when five stomach washings were done. Our findings are in harmony with these observations.

The fasting gastric contents are aspirated by means of a sterilized, Size 16 French nasal catheter. Smaller tubes are used in children and in infants. The tube is passed through the nose more readily, if it is stiffened by keeping it in a refrigerator before use, and if its tip is moistened with sterile glycerine. It can be easily manoeuvered through the nasal cavity, even in the presence of minor submucous bony deformities or of septal deviations. As soon as the tip reaches the pharynx, the patient is instructed to swallow repeatedly while the tube is passed down the oesophagus. There is very little discomfort from this procedure, and the patients readily accept repeated gastric aspirations. By means of a ten-cubic centimeter or twenty-cubic centimeter glass syringe, the gastric contents are removed and are collected in a sterile container. According to the practice of Poulsen and Andersen, the individual specimens are pooled and used for bacteriological examinations. The authors have found that a greater number of positive results are obtained by using pooled specimens than by examining the same number of specimens individually.

An equal volume of 5 per cent. potassium hydroxide is added to the specimen, and the mixture is placed in an oven at a temperature of 45 degrees centigrade for one hour. It is then centrifuged at high speed for thirty minutes, the supernatant fluid is decanted, the sediment is neutralized with 5 per cent. hydrochloric acid, and washed with saline solution. The sediment is then ready for simple smear, culture, or guinea-pig inoculation. For culture, the material is divided among three slants of Petragnani's medium in oval test tubes measuring 155 by 27 by 17 millimeters. The culture tubes are allowed to remain in an almost horizontal position until the moisture has been absorbed by the surface of the culture medium (usually about forty-eight hours). The tubes are then sealed with a mixture of two parts of paraffin to one part of vaseline, and incubated in an upright position until evidence of bacterial growth is noted, or for a maximum period of eight weeks. The cultures are examined grossly every week. Positive findings may be noticeable in three weeks.

The authors believe that the tubercle bacilli can be detected in the fasting gastric contents as competently and reliably by culture as by animal inoculation. The culture method is, of course, simpler and less expensive. On very rare occasions, one may find non-pathogenic acid-fast bacilli in the gastric contents. These can be identified by their morphological and cultural characteristics, and, in case of doubt, by guinea-pig inoculation.

The presence of tubercle bacilli in the fasting gastric contents carries important diagnostic implications. Their ingestion with contaminated milk can be excluded with reasonable certainty, because the patient is not permitted to take nourishment during the night and morning preceding the gastric aspirations. Furthermore, it is unlikely to find viable tubercle bacilli in the milk from tuberculin-negative herds (tuberculosis in cattle has been virtually eradicated throughout the United States), or in milk which has been pasteurized.

The question might arise as to the likelihood of finding tubercle bacilli in healthy individuals who have been exposed to tuberculosis incidentally or professionally (physicians, nurses, and hospital and sanatorium attendants). It has been the authors' experience, and this coincides with the observations of others, that tubercle bacilli are never

TABLE I

PATIENTS WITH TUBERCULOSIS OF THE BONES AND JOINTS WHOSE GASTRIC CONTENTS CONTAIN TUBERCLE BACILLI

Patient	Age in Years	Race	Sex	Diagnosis	Extent of Bone Lesion Shown by Roentgenogram	Pulmonary Findings Shown by Roentgenogram	Classification on Discharge
M. A.	13	White	F	Tuberculosis of right hip joint	Considerable destruction of head of femur and acetabulum	Solitary calcified nodule in right hilum, and small nodular calcifications in left hilum	Healed
R. B.	6	White	F	Tuberculosis of both hip joints	Extensive destruction of head of femur and acetabulum, bilaterally	Increased hilar densities on both sides. Pleural thickening on left side	Healed
B. J.	1½	White	F	Tuberculosis of right hip joint	Destruction of anterior and lateral aspects of femur, extending into epiphysis	Dense bilateral hilar calcifications	Still under observation; improving
M. B.	4	White	F	Pott's disease	Tenth and eleventh thoracic vertebrae, with kyphosis	Few small hilar calcifications	Apparently healed
W. B.	3	Negro	M	Pott's disease	Second and third lumbar vertebrae, with organized psoas abscess	Healed primary tuberculous complex	Healed
L. G.	8	White	M	Pott's disease	Fifth, sixth, seventh, and eighth thoracic vertebrae	Large calcified areas in hilum, bilaterally	Healed
E. K.	8	White	M	Pott's disease	Ninth, tenth, and eleventh thoracic vertebrae, with marked kyphosis	Few calcified nodules in both hilar areas	Improved

found in the fasting gastric juice of healthy persons, or of those with non-tuberculous pulmonary diseases.

Clinically manifest tuberculosis of the tonsils as a source of tubercle bacilli in the aspirated stomach contents is extremely rare, even in patients with long-standing, far-advanced pulmonary tuberculosis. According to Newhart, Cohen, and VanWinkle, a series of 30,676 tonsillectomies showed tuberculosis of the tonsils in 2 per cent. This apparently high figure may not be so startling, if one recalls the incidence of reinfection type of pulmonary tuberculosis found in mass photofluorographic surveys. Roentgenographic evidence of reinfection type of pulmonary tuberculosis existed in from 0.3 to 2 per cent. of the individuals examined. The former figure was recorded in college students. In some of the underprivileged groups, such as recipients of relief and homeless males, the corresponding figures were 4.1 and 16 per cent., respectively. There is no record in the literature of the presence of tubercle bacilli in the gastric contents in persons with latent or subclinical tonsillar tuberculosis, without gross evidence of tuberculous changes in some of the other structures. In the absence of such changes, therefore, the tonsils may be disregarded as a possible source of infection.

The role of tuberculosis of the stomach as a source of tubercle bacilli is insignificant. In a series of 10,000 postmortem examinations, Collinson and Stewart found only three cases of gastric tuberculosis (0.03 per cent.); Gentile reports a collective review of Mirolli, covering postmortem findings in 71,871 cases, which revealed an incidence of 0.21 per cent.; and Sullivan, Francona, and Kirshbaum recorded only two cases of tuberculosis of the stomach in 11,480 postmortem examinations (0.01 per cent.).

Possible sources of tubercle bacilli in the fasting gastric contents are as follows:

1. Frank pulmonary parenchymal infiltration, reinfection type or primary type,

which is readily demonstrable by physical examination or roentgenogram, should be considered. If a specimen of sputum is not available, aspiration of the fasting gastric contents and their bacteriological examination are strongly advocated in the presence of such lesions, even if at first glance the lesions may appear well fibrosed.

2. Tuberculous hilar lymph nodes, which always signify a previous or coexistent primary lesion in the lung parenchyma, may discharge tubercle bacilli into the adjacent bronchi. Incontrovertible experimental evidence was presented by Ulmar and Ornstein that tubercle bacilli, in the absence of cough, are carried from the bronchial tract to the pharynx by the ciliary action of the bronchial mucosa and by the normal bronchial peristaltoid motion. From the pharynx, through swallowing, the bacilli reach the stomach. In rare instances, tuberculous mediastinal lymph nodes may discharge tubercle bacilli directly into the oesophagus.

3. Active tuberculous lesions of the lung parenchyma, or tuberculous lymph nodes which are not visualized on a standard postero-anterior roentgenogram of the chest, may be the sources of tubercle bacilli found in the stomach. The difficulty in visualizing these lesions is due to the fact that they are localized in areas obscured by the heart shadow, the mediastinal structures, or by the dome of the diaphragm.

The group of patients presented here belong to the third category. During the past seven years, twenty-two patients with osseous tuberculosis, in whom an attempt was made to confirm the orthopaedic diagnosis by searching for tubercle bacilli in the fasting gastric contents, were treated at the Muirdale Sanatorium. In none of these patients was active pulmonary tuberculosis demonstrated by roentgenogram. The gastric contents were negative in fifteen patients, who had a total of eighty-one gastric aspirations. Seven patients, whose gastric specimens were positive for tubercle bacilli, had forty-six gastric aspirations. There were four cases of Pott's disease and three cases of tuberculosis of the hip joint in the positive group.

Concerning the finding of tubercle bacilli in the stomach contents of patients with orthopaedic forms of tuberculosis, the following points deserve consideration.

1. What is its diagnostic significance? It is the consensus of clinicians that this finding indicates an active tuberculous focus in the body,—usually a tuberculous lesion in the lung parenchyma or in its collateral lymph nodes. In the presence of an orthopaedic involvement of obscure origin, the presence of tubercle bacilli in the fasting gastric contents, though not absolute proof of the tuberculous nature of the disease, should be looked upon as important presumptive or circumstantial evidence.

2. If the assumption is correct that tubercle bacilli in the stomach indicate active tuberculosis, no patient with tuberculosis of the bones or joints should be pronounced cured until repeated bacteriological examinations of the gastric contents are negative for tubercle bacilli. So long as these cultures remain positive, there is a potential danger of spread of the micro-organisms to other parts of the lung, to the bone lesion being treated, or to other hitherto uninvolved structures or organs of the body. It is reasonable to believe that the same tuberculous focus which is discharging tubercle bacilli into the bronchial tree is discharging micro-organisms into the blood stream. The authors believe that healing this source of infection before releasing the patient from treatment would constitute the safest way of avoiding a breakdown of an apparently well-healed bone lesion and of preventing tuberculous complications, such as pulmonary spread or meningitis, which might prove fatal. The frequent incidence of such complications shows the need for a revision of the general management of these cases.

3. Tubercle bacilli passing from the respiratory tract to the stomach are necessarily found in the pharynx during one phase of their passage. Coughing, sneezing, laughing, and crying may expel them into the air, directly exposing all who are in close contact. Coughing may be brought about not only by the tuberculous lesion in the lung or in the lymph nodes, but also by intercurrent non-tuberculous diseases, such as the so-called

common cold, upper respiratory infections, simple or allergic bronchitis, influenza, bronchopneumonia, measles, whooping cough, and a number of others. Although the spread of tubercle bacilli from these patients to those in their environment is not so massive as in the case of an open, advanced pulmonary tuberculosis, nevertheless the risk of infection exists. Undoubtedly, these patients are tuberculosis carriers, and therefore the entire regimen of their management should be revised accordingly.

CONCLUSIONS

1. From the standpoint of optimum therapeutic results and of the prevention of possible local or general complications, the importance of the early diagnosis of tuberculosis of the bones and joints cannot be overemphasized.

2. Because of the inherent limitations of the available physical and roentgenographic methods of examination, the diagnosis of orthopaedic forms of tuberculosis is difficult to establish.

3. Similar limitations are encountered in many cases of pulmonary tuberculosis, the demonstrable evidence of which would give a clue to the diagnosis of an obscure bone or joint disease. Not all active tuberculous lesions of the lung are visible on the standard postero-anterior chest roentgenogram. Small lesions, which may be discharging numerous tubercle bacilli into the blood circulation, may remain obscured by the heart shadow, the mediastinal structures, or the diaphragm.

4. For the sake of accurate diagnosis, it is imperative to resort to methods which are of value in uncovering these hidden sources of tubercle bacilli. Roentgenograms of the chest taken at various angles, such as oblique and lateral exposures, or special apical detail film, are of assistance, but roentgenographic shadows in the lung fields do not identify the etiology of the lesion.

5. The available data in the literature, as well as the authors' experience with over 2,000 cases of pulmonary tuberculosis, indicate that examination of the fasting gastric contents for tubercle bacilli is an indispensable diagnostic procedure. The same method is applicable to orthopaedic forms of tuberculosis.

6. Examination of the fasting gastric contents should be carried out periodically, at intervals of from three to six months, to ascertain the course of the original tuberculous focus in the lung.

7. The conception of complete healing of a tuberculous lesion of a bone or joint should be expanded. No patient should be classified as cured until repeated bacteriological examinations of the gastric contents reveal no tubercle bacilli. Although this may prolong the treatment, there cannot be any doubt that this added regimen is of value in consolidating the healing of the orthopaedic lesion, as well as that of the original source of the disease.

8. Securing gastric contents for bacteriological examination is a simple procedure which can be carried out by the physician or by a trained attendant, with very slight discomfort to the patient.

9. The detection of tubercle bacilli in the fasting gastric contents is as competent and reliable by culture as by animal inoculation.

10. A higher number of positive results are obtainable when five consecutive gastric specimens are examined than where fewer samples are studied. A greater number of positive results may be expected from examination of pooled specimens than from separate examinations.

11. In a group of patients with various forms of orthopaedic tuberculosis, an attempt was made to corroborate the diagnosis by the bacteriological examination of the fasting gastric contents. Out of this group of twenty-two patients, tubercle bacilli were found in seven (31.8 per cent.).

12. With improved laboratory technique and with more frequent examinations of this type, a higher percentage of positive findings may be expected.

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FRACTURE OF THE MEDIAL EPICONDYLE WITH DISPLACEMENT INTO THE ELBOW JOINT *

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A great deal has been written in the last quarter century about displacement of the medial epicondyle into the elbow joint, and a gradual development in the diagnosis and treatment of this unusual condition can be traced in the literature. The first descriptions of manipulative reduction of the incarcerated medial epicondyle were made independently by Fèvre and Roudaitïs (1933) and by Roberts (1934). A comprehensive paper on the whole subject (based on forty-one collected cases) was read by Clarke at the meeting of the Manchester Surgical Society in 1939. Unfortunately, his paper has not yet been published.

Fracture of the medial epicondyle with incarceration in the elbow joint occurs mainly between the ages of ten and seventeen, and is often associated with a traction injury to the ulnar nerve. The condition may occur in either of two ways.

1. As a result of a fall on the hand, the forearm is abducted on the humerus and the strain on the medial collateral ligament avulses the epicondyle. The epicondyle is pulled down to the level of the elbow joint, into which it is sucked by the momentary vacuum which forms in the joint.

2. A posterolateral dislocation of the elbow is associated with a fracture of the medial epicondyle. The epicondyle, being still attached to the medial ligament of the elbow, is displaced along with the radius and ulna. When the dislocation is reduced, the epicondylar fragment lags behind the forearm bones as they pass into position over the articular surface of the lower end of the humerus. Thus only a pseudoreduction is accomplished, in which the epicondyle remains between the coronoid process and the humerus, and a subluxation remains. The epicondyle lies in the joint, with its raw bony surface in contact with the articular cartilage of the coronoid.

This second type of incarceration, following reduction of a dislocation, is the more important, for it is in such cases that the diagnosis is most often missed. In all cases a subluxation is present, although it is only of secondary importance, for, if the incarcerated fragment is replaced early, the subluxation automatically disappears.

Clinical diagnosis is relatively easy, if paralysis of the ulnar nerve is detected. If a good anteroposterior roentgenogram is obtained, there can be no doubt about the position of the epicondyle, but owing to pain and muscle spasm the roentgenologist will frequently be unable to extend the elbow sufficiently for this purpose.

Reduction can often be effected by manipulation, either by abduction of the forearm on the humerus, accompanied by supination and extension of the wrist and fingers to tense the flexor muscles and so pull the epicondyle out of the joint; or by adduction of the forearm on the humerus, associated with flexion and extension movements of the elbow, with the object of expressing the epicondyle, as an orange pip may be expelled by compressing it between the finger and thumb. Clarke has referred to several cases in which spontaneous extrusion has occurred.

When manipulation fails, open operation is necessary, and it is generally recommended that at this time the ulnar nerve should be transposed anteriorly. Various references are made in the literature to the danger of a late ulnar neuritis developing from friction of the ulnar nerve on the rough epicondylar groove in those cases in which anterior transposition has not been carried out.

When incarceration of the epicondyle remains unrecognized for several weeks, open operation becomes very difficult, and even when the epicondyle has been excised, or the

* Read at the meeting of The British Orthopaedic Association, London, June 1, 1945.

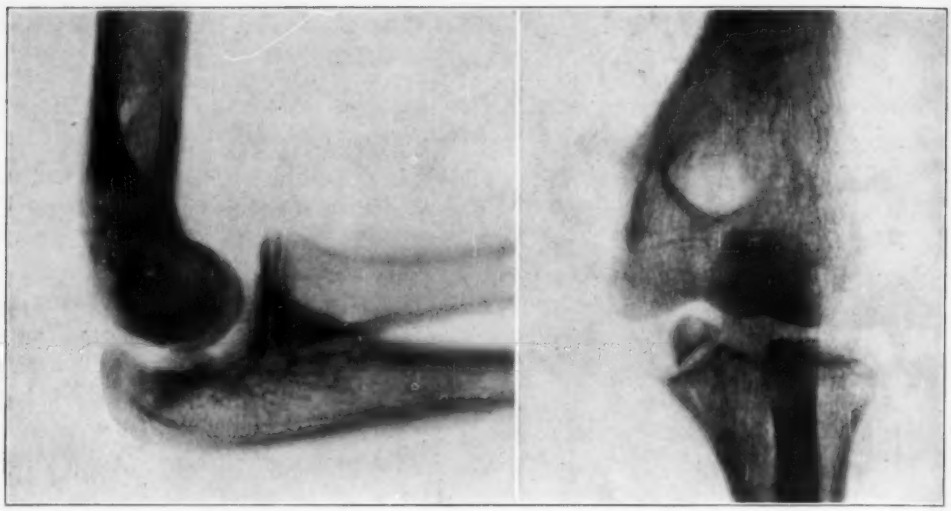

FIG. 1-A

The incarcerated medial epicondyle is seen at the joint level in the lateral roentgenogram.

FIG. 1-B

This anteroposterior roentgenogram could be obtained only by extending the elbow under anaesthesia.

fracture has been reduced, the subluxation almost defies reduction. The final results in late cases treated by operation appear to be uniformly poor; such patients are usually left with a very limited range of movement.

The following observations are based on a series of twenty-one cases treated by the author during the last five years.

The *first problem* which presented itself in investigating this subject was how to make an early and definite diagnosis. Forty per cent. of the patients had no paralysis of the ulnar nerve; therefore clinical diagnosis was not always easy and reliance had to be placed on the roentgenogram. The presence of pain and muscle spasm often prevents the patient from extending his elbow beyond a right angle. As a result, the anteroposterior roentgeno-

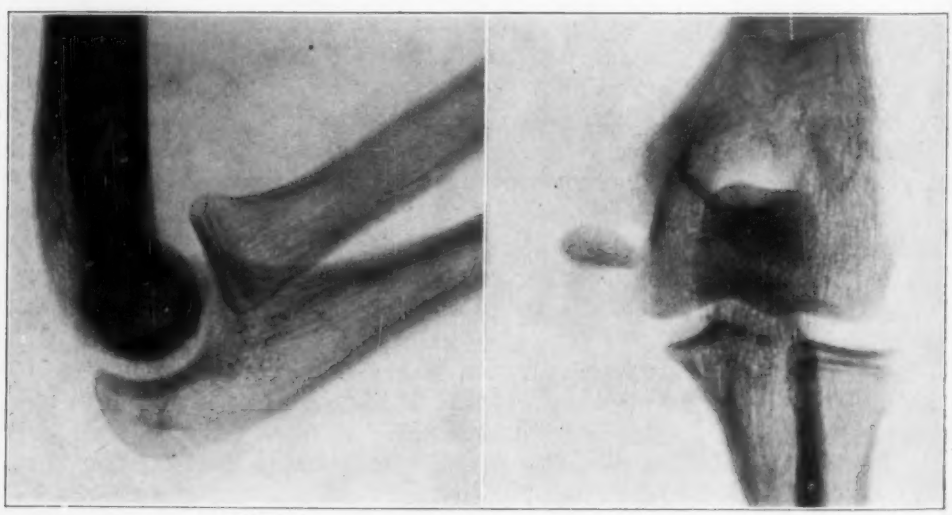

FIG. 2-A

The medial epicondyle can no longer be seen in this lateral roentgenogram. (Compare with Fig. 1-A, taken before reduction.)

FIG. 2-B

The medial epicondyle, now released from the joint, lies above the level of the joint line.

gram needed for accurate diagnosis cannot be obtained, and a lateral view must suffice. If, however, the epicondyle can be seen at the joint level in the lateral view, it may be considered to be in the joint. On reviewing our last 100 cases of simple medial epicondyle fracture, in no instance could the medial epicondyle be seen at the joint level in the lateral roentgenogram. In simple medial epicondyle fracture, the fragment apparently is never pulled down as far as the joint level. Figure 1-A shows the typical appearance, in the lateral view, of a fragment incarcerated in the joint. Diagnosis was based on this view alone, and was confirmed only after the patient had been anaesthetized and a good anteroposterior view had been obtained (Fig. 1-B).

The *second problem* was how to effect an easy and safe reposition of the fragment. In the patients seen by the author, only 40 per cent. of the early fractures were reduced by manipulation, although Clarke and Roberts claim a much higher percentage of success. The standard methods of manipulative reduction, however, may cause a further traction injury to the ulnar nerve. In two of our patients, who initially had no paralysis of the ulnar nerve, a complete nerve lesion appeared after manipulation had been attempted, and lasted for several months. Clarke also refers to patients showing a more profound degree of paralysis of the ulnar nerve, following manipulative reduction.

Reduction of the incarcerated medial epicondyle was carried out in the last six cases in the following manner: The patient was anaesthetized, the forearm gently abducted on the humerus, and faradism applied to the flexor muscles with the wrist held in extension. In all cases the displacement of the medial epicondyle was thus easily reduced, and subsequent treatment was carried out as for a simple epicondyle fracture. The six patients in whom reduction was achieved by faradism were, of course, all early cases. In only one instance had the duration of the injury been five days; in this case, a strong continuous faradic contraction was required, and an audible click was heard as the epicondyle left its lodgment against the coronoid. Figure 2-B shows the roentgenogram after reduction by faradism. The subluxation has simultaneously disappeared. The medial epicondyle is no longer visible at the joint level in the lateral roentgenogram.

FIG. 3

This patient had a fracture of the medial epicondyle, displaced into the elbow joint, and inadvertently left unreduced. This photograph shows motion possible five years after injury.

Should faradism not be available, manipulation is more likely to be successful under very light anaesthesia than under deep anaesthesia.

The *third problem* was how to treat a patient whose injury had been unrecognized for five weeks or more. As already stated, the usual method is to operate, extract the fragment, and by the exercise of extreme force and possibly division of the remaining joint ligaments, reduce the subluxation. Such treatment usually results in extreme and permanent limitation of elbow movements. There is one suggestive point which can regularly be observed in the pathological changes in these cases. At operation, the raw bony surface of the epicondyle is found to be firmly adherent to the coronoid process; when the epicondyle has been removed, erosion of the articular cartilage on the coronoid is evident. The muscle and periosteum-covered parts of the medial epicondyle in contact with the trochlea, however, produce no such reaction. No adhesions form between these two apposing surfaces, and erosion of the trochlear cartilage does not take place.

This pathological observation suggests that better results might be obtained in late cases by leaving the epicondyle incarcerated in the joint. Mechanically, the presence of

the epicondyle in the medial compartment of the joint renders the subluxation stable (see Figure 1-B). If the epicondyle is removed from the joint by operation, and the subluxation cannot be reduced (as is sometimes the case), a rather unstable joint results.

This line of conservative treatment was inadvertently carried out in a lad who sustained his initial injury in 1940. He was not seen again until 1945. By that time the medial epicondyle had become fused to the coronoid process, and Figure 3 shows how excellent were the patient's elbow movements. He still had a partial paralysis of the ulnar nerve, which, incidentally, was due to constriction of the nerve by a fibrous band. At operation on the nerve, the interior of the joint and the epicondylar fragment were seen to be covered by a smooth layer of what appeared to be fibrous tissue. The articular cartilage of the trochlea showed no erosion, and no intra-articular adhesions were present.

A bony fusion of the fragment to the coronoid, however, does not always occur. In another case of unreduced fracture, seen eighteen years after the injury, there was only a fibrous union to the coronoid, but, although marked osteo-arthritic masses of bone had formed at the sides of the joint, function was even better than that shown in Figure 3.

The *fourth problem* was how to deal with the associated paralysis of the ulnar nerve. The nerve is damaged by traction, and it would seem that it should recover at least as readily in its normal bed as in a new course made for it in front of the elbow. The one argument against leaving the ulnar nerve alone is that friction with the rough edge of the bone in the epicondylar groove may result in permanent changes in the nerve or, even if recovery occurs, may give rise to a late ulnar neuritis. When such patients are operated upon, however, no sharp bony edge is apparent in the epicondylar groove, the base of the groove being covered with smooth fibrous tissue. Furthermore, if the possibility of such damage existed, one would expect to find a delayed lesion of the ulnar nerve in at least a proportion of the numerous cases of simple fracture of the epicondyle observed in children or in adolescents. The author has never encountered a late ulnar neuritis following such an injury, and Seddon, in the Peripheral Nerve Unit at Oxford, could find among his records no case of late ulnar neuritis following an uncomplicated fracture of the medial epicondyle in adolescents. It seems, therefore, that fracture of the medial epicondyle by itself rarely, if ever, gives rise to ulnar neuritis. Late ulnar neuritis may occasionally follow such an injury associated with dislocation of the elbow, but in this instance it appears to be the soft-tissue damage and the ensuing scarring which cause the neuritis, rather than friction in the epicondylar groove.

In the author's cases of incarceration of the medial epicondyle associated with a lesion of the ulnar nerve, the nerve was left alone and, in all but one instance, recovery occurred within a year. In the one exception (Fig. 3), the persisting nerve lesion was found at operation to be due to constriction by a fibrous band one-half inch above the level of the medial epicondyle.

When the medial epicondyle remains permanently in the joint, a late ulnar neuritis may result, due to subsequent osteo-arthritis and the persistent cubitus valgus deformity, and an anterior transposition of the ulnar nerve may be necessary.

SUMMARY

1. In cases of fracture of the medial epicondyle with displacement into the elbow joint, diagnosis often rests mainly on the roentgenogram. A satisfactory anteroposterior view may be difficult to obtain, but if, in the lateral roentgenogram alone, the epicondyle can be seen at the joint level, it may be regarded as being in the joint.

2. Reduction in early cases can easily be accomplished by anaesthetizing the patient, gently abducting the forearm on the humerus, and applying faradism to the flexor muscles.

3. Cases unrecognized for more than a few weeks are probably best left alone and not subjected to operative reduction.

4. Immediate anterior transposition of the ulnar nerve is unnecessary.

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CONTRACTURE OF THE SCALENUS ANTERIOR, CAUSING ANEURYSMAL VARIX OF RIGHT INTERNAL JUGULAR VEIN

A CASE REPORT

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The scalene syndrome is an interesting diagnostic problem. Neurological and vascular disturbances in the upper extremity may be caused by pressure from a contracted scalenus anterior muscle on the underlying brachial plexus cords and subclavian artery.

Possible etiological agents are congenital, associated with cervical rib; traumatic, following apparently minor strain; and neurological, when evidently secondary to cervical nerve-root irritation. Common sequelae are peripheral neuralgia and circulatory deficiency in the upper extremity.

H. A., a white female, thirty-eight years of age, was first seen on May 7, 1945, and gave a history of pain in the right shoulder of insidious onset ten months before, progressively becoming more severe. There was no definite history of trauma. Treatment elsewhere for bursitis of the shoulder by physiotherapy and anaesthetic injection had given no relief. The woman had been forced to give up her occupation as a beauty-shop operator; she became very apprehensive about her condition, and developed an apparently unrelated axillary dermatitis which was identified by a dermatologist as seborrheic in type. There were no objective neurological or circulatory signs in the extremity. There was palpable tightness of the scalenus anterior, with radiated pain in the shoulder and arm when pressure was sustained. Roentgenograms revealed a normal cervical spine.

Surgical exploration was performed on June 5, 1945, and, after retraction of the lateral margin of the sternocleidomastoid, a sac containing fluid expanded into the incision. This proved to be a saccular dilatation of the internal jugular vein, about three centimeters in diameter. The vein was ligated above and below the sac, which was excised, exposing the right lymphatic duct and the scalenus anterior. The muscle was definitely tight and somewhat thickened; so it was sectioned above its insertion. After closure the wound healed well, there was complete relief of symptoms, and no evidence of vascular insufficiency. Microscopic section added nothing to the gross diagnosis of aneurysmal varix.

This case presents apparent interference with the venous flow in the right internal jugular vein by compression of the scalenus anterior, causing an aneurysmal dilatation of the vein in the base of the neck. The right internal jugular vein is the larger and normally deviates farther laterally than its associate, the carotid, at the base of the neck. Apparently in this instance the junction with the subclavian vein to form the innominate was more lateral than usual, allowing the pressure from the scalenus anterior.

SURVIVAL OF THE HEAD OF THE RADIUS IN A CHILD AFTER REMOVAL AND REPLACEMENT

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In a paper published some years ago it was emphasized that the head of the radius should not be removed in children, as its removal would interfere with the growth of the forearm.[1] The writer had not previously seen a head of the radius which was completely detached and which then was replaced and survived, nor has he observed a report of any such case.

On March 11, 1944, a boy, eleven years old, was brought into the Hospital on account of a fracture of the proximal end of the radius. According to the history, the elbow had been dislocated, and the dislocation had been reduced on the previous day. However, the head of the radius was displaced in the posterior portion of the joint. The patient was operated upon the following day, approximately forty-eight hours after his original injury.

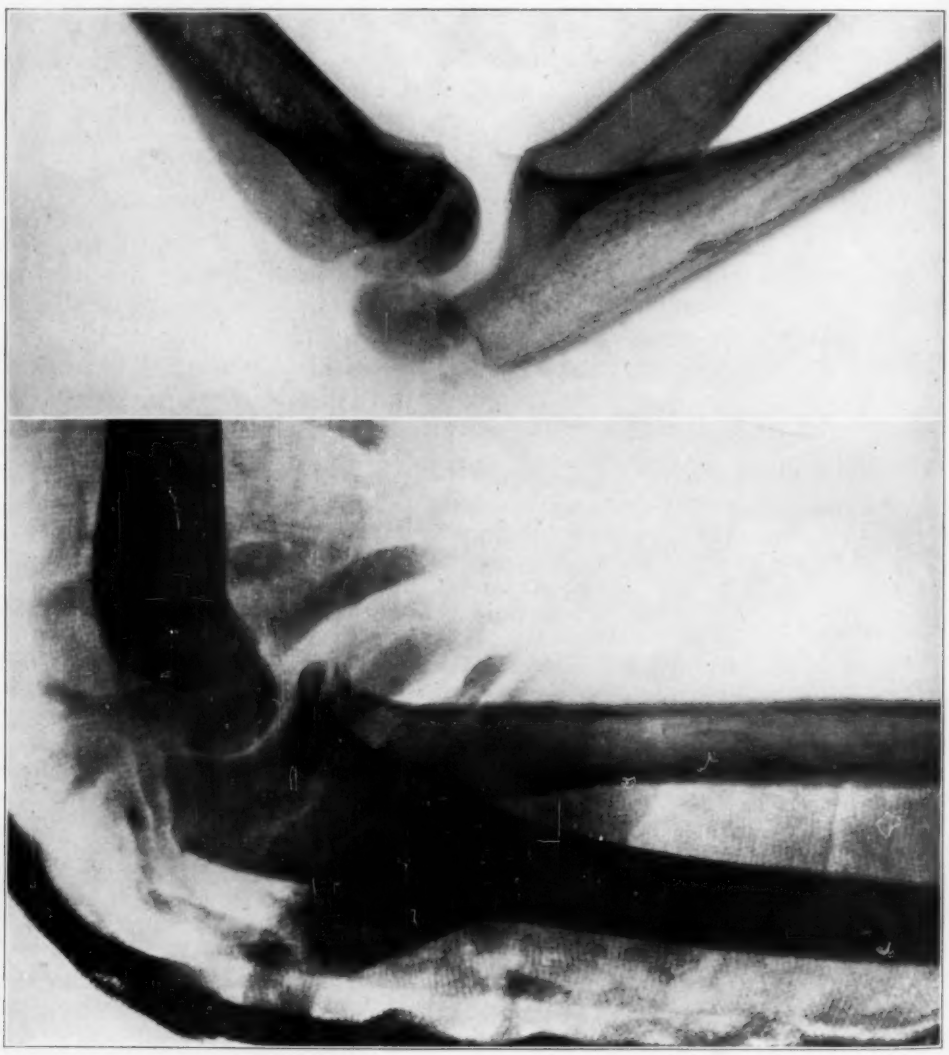

FIG. 1

Dislocation of the head of the radius. Preoperative and postoperative views.

FIG. 2

Anteroposterior and lateral views of the same elbow about thirteen months later. Function is approximately normal.

The elbow joint was opened by a posterolateral incision, extending from the epicondyle of the humerus downward along the anterior border of the anconeus. The head of the radius was found in the posterior portion of the joint behind the external condyle (Fig. 1). It was completely free, and was lifted out with toothed forceps and placed in a towel on the instrument table. The stump of the neck of the radius was then exposed, and the head was replaced in approximately its normal position. The elbow was flexed to 90 degrees, and the soft tissues were sutured around the head. The fragment of the head included the epiphyseal line. The wound was closed, and the elbow was immobilized in a posterior plaster mold. The patient left the Hospital a few days later, and the convalescence was uneventful. Immobilization was continued for eight weeks, at the end of which time the cast was removed, and the patient was advised to use the arm with care.

He returned for a check-up examination a little over thirteen months after the operation. Movement of the elbow was almost normal, there being approximately 5 degrees' less extension than on the normal side. There was no pain; the arm seemed strong; and there was satisfactory growth of bone, although the late roentgenograms (Fig. 2) showed an irregularity of the epiphyseal plate.

This case is reported because it is a clinical example, supporting the statement that epiphyses should not be removed in children. If the epiphyses are found to be displaced, they should be replaced, because they may survive, even though they are completely without blood supply.

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SEVERE PELVIC FRACTURES TREATED BY FIXED SKELETAL TRACTION

Report of a Case

BY MAJOR J. D. FARRINGTON
Medical Corps, Army of the United States

Pelvic fractures are usually treated satisfactorily either in a canvas sling with continuous traction, as described by Key and Conwell, or by plaster fixation after reduction. The reduction may be accomplished by lateral recumbency, according to the method of Watson-Jones.

Occasionally one is confronted with multiple fractures, in which the entire half of the pelvis has been displaced medially. Some method of forceful lateral traction must be applied to reverse the compressive force which produced this type of injury. The problem is similar to that encountered in central dislocation of the head of the femur. Continuous lateral traction has produced good results in reducing the fracture, but requires long recumbency, constant surveillance, and a great deal of nursing care.

Immediate reduction and immobilization of fractures in plaster-of-Paris is the ideal treatment when such factors as transportation over long distances, or the strain on hospital and nursing facilities in overseas hospitals, must be considered. When continuous traction is employed, pulmonary complications, decubitus ulcers, and phlebothrombosis are constant threats, unless individual nursing care is instituted.

CASE REPORT

A white soldier, aged twenty-three years, was injured on February 1, 1944, when he fell from a control tower at a base in the South Pacific area. The soldier was descending a vertical wooden ladder, wet with rain, and slipped at a measured height of fifty-two feet, falling free to strike a packed coral surface. The full impact of the fall was concentrated against the right trochanter. On admission to the hospital, thirty minutes after the injury, the patient was in a state of moderate shock, and complained of severe pain throughout his pelvis and lower back. This was increased by any movement of his lower extremities. Roentgenograms (Fig. 1) revealed multiple fractures of the pelvis with anterior rotation and medial displacement of the main fragment, consisting of the greater part of the ilium, the acetabulum, and the ischium. The iliac fracture was parallel to the sacro-iliac joint. There was boardlike rigidity of the entire abdomen, with exquisite tenderness over the bladder. Approximately 250 cubic centimeters of bloody urine were obtained by catheterization. The surgical consultant explored the bladder, repaired a tear at its base, and inserted a large suprapubic de Pezzer catheter. A urethral catheter was also inserted. The general condition of the patient prevented any immediate definitive treatment of the fractures. He was put to bed, and skin traction was applied to the widely abducted right lower extremity. Three transfusions of whole blood, each of 500 cubic centimeters, were given during the first six days. Pain was severe and constant, and nursing care was a problem.

After consideration of the roentgenograms, fixed lateral skeletal traction and immediate plaster immobilization were decided upon. To this end, the apparatus pictured in Figure 2 was set up. The skeletal reduction frame was placed transversely on the operating table, with the portable fracture table placed over it on a narrow wooden platform, just high enough to allow the entire reduction frame to be moved freely in any direction.

Fourteen days after the injury, when the patient's general condition had improved a good deal, he was given a general anaesthetic, and a femoral twin-pin unit was inserted into each trochanter. The patient was then placed on the fracture-table saddle, and the twin-pin units were fixed in the fracture frame. Satisfactory reduction was obtained by traction on the right femoral twin-pin unit, aided by manual pressure against the right iliac crest. With this method, the traction was against the fixed left side of the pelvis, and, after reduction, the right side could be locked in place. A double hip spica cast was applied from the costal margins to the toes, because it was believed that the patient would be more comfortable with the hamstring muscles immobilized.

The change in the general condition of the patient was gratifying. Whereas, prior to immobilization, frequent doses of morphine were necessary to control pain, none were required after the application of the cast. The patient was turned every two or three hours with no discomfort, and nursing requirements were reduced to a minimum.

The patient was scheduled for evacuation one week after application of the cast, but this had to be

FIG. 1

Roentgenogram of pelvis after patient had fallen fifty-two feet.

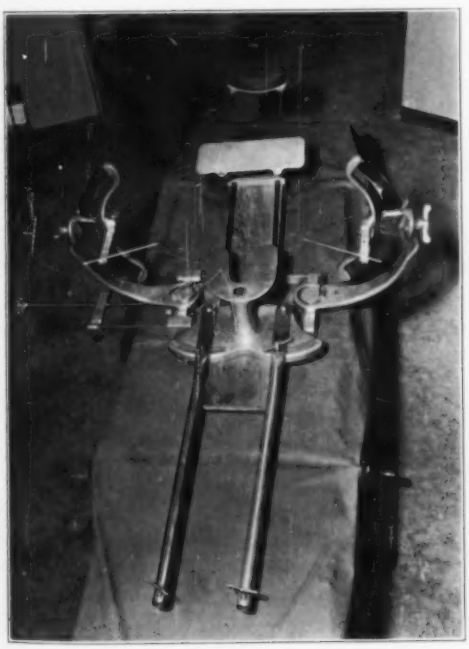

FIG. 2

FIG. 3

FIG. 2: Combination apparatus set up for reduction of fractures. Arcs of the reduction frame are turned longitudinally. Entire reduction frame may be moved in any direction, beneath the support for the fracture table, to facilitate engagement of the femoral units.

FIG. 3: Surgical technician demonstrating position of patient in the apparatus.

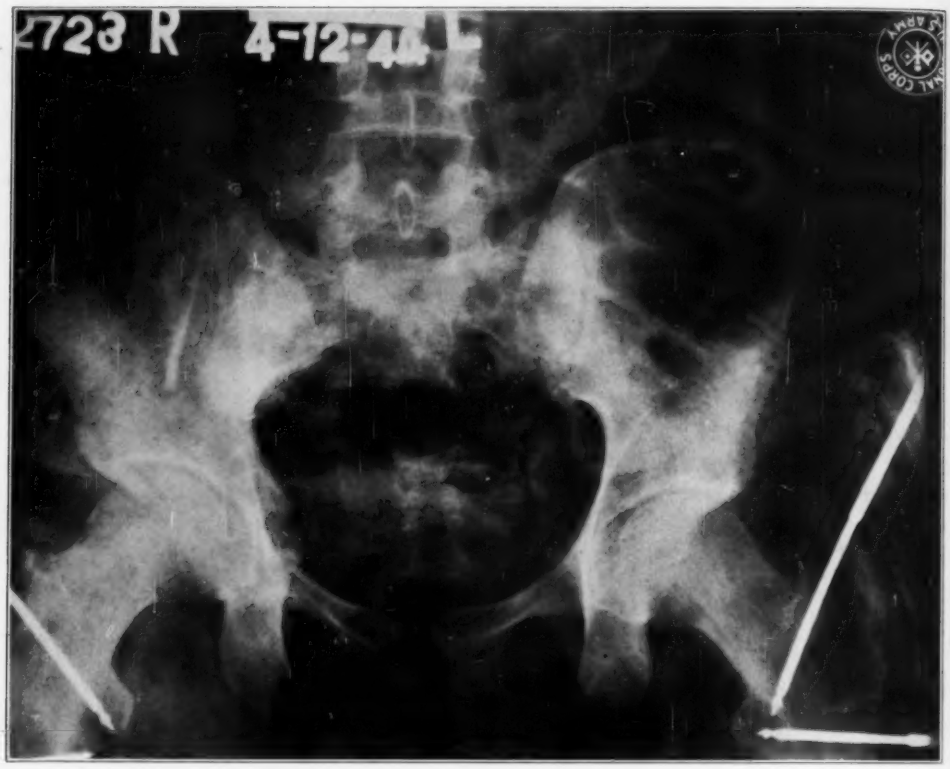

FIG. 4

Roentgenogram of pelvis fifty-seven days after reduction of multiple fractures. Pelvic ring and contour of right ilium restored.

postponed, because of the development of acute pyelitis with high temperature. This complication cleared up with adequate therapy, and did not recur.

On March 14, 1944, four weeks after reduction of the fracture, the patient began to complain of pain when turned, due to looseness of the cast from loss of weight. He was again placed on the fracture table with the twin-pin units locked in the reduction frame to maintain position; the old cast was removed, and a double hip spica cast to the knees was applied. A basal anaesthesia, consisting of one-quarter grain of morphine and 1/150 grain of scopolamine, was adequate for this procedure.

On March 26, the patient was evacuated in plaster; at that time he was comfortable, afebrile, and was voiding urine spontaneously. The suprapubic wound had healed. Roentgenograms (Fig. 4), taken on April 12, 1944, while the patient was still in the second cast, revealed that reduction had been maintained. At the time of last correspondence, the patient was out of plaster, but not yet ambulatory.

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TRICHINOSIS AS A CAUSE OF MERALGIA PARAESTHETICA

BY HAROLD H. COHEN, M.D., NEW YORK, N. Y.

From the Beth David Hospital, New York

Meralgia paraesthetica was first described by Bernhardt in 1895. The clinical syndrome is one of paraesthesia, pains, and some objective sensory loss over the anterolateral aspect of the thigh, which is believed to be the result of a hyperplastic reaction of the nerve sheath of the external femoral cutaneous nerve. The sensory disturbances consist of various forms of paraesthesia of the outer side of the thigh, sometimes with diminished sensation or hypaesthesia. The symptoms may persist for years and produce a good deal of discomfort, exaggerated by walking or by the touch of clothing. The disease has been considered a neuritis, which originates in the nerve when it passes under the inguinal ligament, deep and just medial to the anterior superior iliac spine. The condition is said to occur more frequently in men; in 1900 Musser and Sailer collected ninety-nine cases, of which seventy-five were in men. A large number of cases are attributable to single or repeated trauma to the nerve, such as pressure from a belt or corset over the anterior superior spine. Pregnancy and obesity are mentioned among the causes, as well as static disturbances, such as weak feet.

The peculiar anatomical location of the lateral femoral cutaneous nerve in its passage over or under the sartorius muscle, as well as its proximity to the anterior superior iliac spine, renders it extremely susceptible to compression from any lesion of the sartorius or its fascia. Thus in the majority of cases, an abnormally placed fibrous band may be responsible for the pressure neuritis. The case to be reported disclosed such a fibrous band, which on microscopic study proved to be caused by trichinosis. Further investigation not only revealed the probable time of invasion of the trichinae, but also gave a positive intradermal test. Although a survey of the literature revealed myositis to be a constant finding in trichinosis, its possible relationship to meralgia paraesthetica has not heretofore been mentioned. Clinically, the muscles most affected by the migration of the larvae through the blood stream are the gastrocnemius, deltoid, biceps, and those around the eye; less often the muscles of the diaphragm, abdominal wall, and thorax are affected; rarely, but of greater seriousness, the intercostals, muscles of mastication, deglutition, and speech, and occasionally the cardiac musculature, are involved.[2]

CASE REPORT

D. N., a male, aged forty-two, was first seen by the author on October 13, 1944; the patient complained of coldness and numbness of the anterolateral aspect of the right thigh of four years' duration. The complaints were preceded by "pins and needles" and by hot and cold sensations over a small circular area of the distal and outer portion of the thigh. The paraesthesia would last for about half an hour, subside, and then recur at variable intervals. At first the symptoms were most noticeable at night and interfered with sleep, but they were soon followed by paraesthesia during the day. Walking increased the severity of the pain and the number of attacks. After one year of the paraesthesia, the patient first noted numbness of the greater part of the outer thigh. The numbness was present chiefly on arising in the morning; by night the patient was tormented with sensations of pins and needles and ho and cold flushes over the anterolateral aspect of the thigh. The numbness soon became steady by day, and was the chief complaint when the patient was first seen by the author. In addition to the large area of numbness, there was a smaller area of "burning", located several inches below the anterior superior spine, so that even the rubbing of clothes against the skin became painful.

The past history was interesting in that five years before, after eating pork, the patient had become quite ill, with fever and diarrhoea.

The physical examination revealed a well-developed muscular male, who appeared to be in excellent general health. Examination of the right thigh revealed normal musculature and muscle tone. There was no restriction of motion in the hip, knee, or ankle. The peripheral circulation was unimpaired. The abdominal examination was entirely negative. Gross neurological examination revealed marked hypaesthesia to pinprick over the anterolateral aspect of the thigh, corresponding to the dis-

tribution of the external cutaneous nerve. Pressure over this nerve, immediately below the anterior superior iliac spine, resulted in pain, radiating down the course of the nerve. Ankle jerks and knee reflexes were unimpaired, and no abnormal reflexes could be obtained.

Roentgenographic examination of the pelvis and right femur failed to disclose an osseous lesion.

On December 2, 1944, with novocaine infiltration anaesthesia, the superficial and deep fascia of the thigh were exposed through a six-inch hockey-stick incision, extending for three inches along the anterior crest of the ilium to the anterior superior spine, and then distally for an additional three inches. Incision of the deep fascia disclosed the interval between the sartorius and tensor fasciae latae, revealing the lateral femoral cutaneous nerve. This was traced proximally to the anterior superior iliac spine, where it was found rather deeply placed in the osseous hollow immediately below the spine. Here the nerve was markedly encroached upon by a thick fibrous band. The band was in intimate contact with, and appeared to be part of, the inferior surface of the sartorius. A probe, which was passed proximally along the nerve, was stopped by the dense constriction. The fibrous band was carefully excised, revealing a thinned segment of the nerve. At this point the patient exclaimed that the numbness of the thigh had disappeared. A probe could now be passed easily beneath the inguir [1] ligament. Closure was performed, using plain catgut for the subcutaneous tissue and silk for the skin. An alcohol dressing was applied, and was overlaid with several gauze bandages for pressure.

At biopsy, the gross specimen consisted of a small fragment of striated muscle and intervening fibrous tissue, measuring 1.5 centimeters in length and 0.5 centimeter in width.

Microscopically, the section revealed muscle fibers, which were partly fragmented and showed signs of degeneration and fibrosis. Part of the muscle was entirely replaced by fibrous tissue. There was increased fat tissue between the muscle fibers. Numerous cysts of *Trichinella spiralis* were scattered throughout the section. None of the cysts were calcified, and there was no cellular infiltration around the cysts.

Laboratory findings after the operation revealed a positive skin test for trichinosis, and a negative precipitin test. The complete blood count showed a hemoglobin of 97 per cent.; red blood cell count 4,930,000; white blood cell count 13,600; color index 0.99; total polymorphonuclear neutrophils 66 per cent., of which 59 per cent. were segmented and 7 per cent. were non-segmented; eosinophils 4 per cent.; basophils 1 per cent.; lymphocytes 25 per cent.; and monocytes 4 per cent. There were no abnormal blood cells.

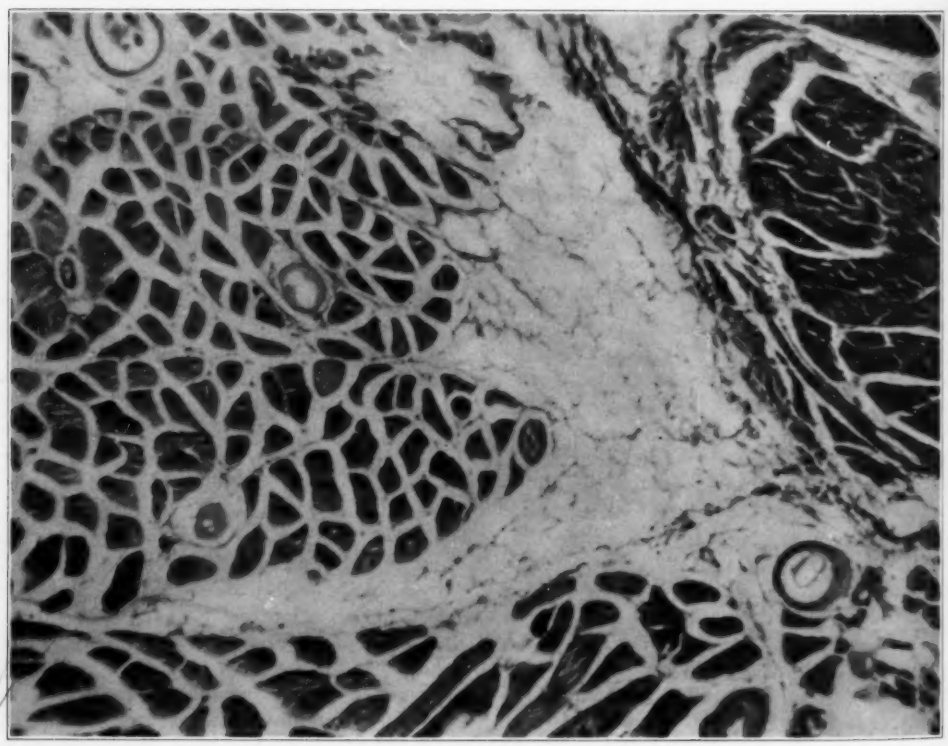

FIG. 1

Low-power view of fibrous band, showing mulitple cysts of *Trichinella spiralis*.

FIG. 2

High-power view of cyst of *Trichinella spiralis*.

FIG. 3

High-power view, showing muscle degeneration and fibro-fatty replacement of muscle. Note absence of round-cell infiltration.

The diagnosis was chronic fibrous myositis and trichinosis.

The postoperative course was complicated by the development of a hematoma, which delayed healing for several weeks. The patient was last seen four months after operation, and stated that the numbness of the thigh had almost completely subsided, and that there had been a return of normal temperature sensations to the thigh. Objectively, the hypaesthesia to pinprick had completely disappeared, with the exception of a small patch, the size of a fifty-cent piece, immediately below the anterior superior spine.

NOTE: The author wishes to express his appreciation to Dr. Gudeman, of the Department of Pathology, for assistance in the interpretation of the pathological material.

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LOCALIZED COCCIDIOIDOMYCOSIS OF BONE

Report of a Case

BY CAPTAIN M. L. GOREN
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Coccidioidomycosis, or infection caused by the *Coccidioides immitis*, was first described by Rixford and Gilchrist in 1896. The fungus producing this infection is diphasic. In the *saprophytic* phase, it consists of septate hyphae, which appear white and cottony on solid media, and become pigmented with age. The infective portion of the fungus presumably occurs in nature in the form of chlamydospores. In the *parasitic* phase in animals, the fungus is made up of sporangia, or spherules.[1] In the living organism the chlamydospores round up into spherules, and cleavage planes divide the protoplasm into segments, which develop into endospores within the double refractile wall. Mature spherules may vary from ten to sixty microns in diameter, or may even be as large as 200 microns in diameter. The endospores may be arranged radially, or grouped in the center. The spherule wall ruptures, and releases the endospores to spread in the animal and grow into mature spherules. Spread in the animal is by way of the blood stream or the lymphatics. In nature, the fungus is limited to certain arid regions. Its host is unknown, although Emmons suggests a rodent reservoir.

The problem of coccidioidomycosis has been emphasized in the present war, due to the training of a large number of troops in the arid Southwest, where *Coccidioides immitis* is endemic. The disease has protean manifestations, and has both immediate and latent effects on the infected host.

Smith [7] divides the disease into the following categories:

1. Initial or primary infection:
   (a) Inapparent or asymptomatic form;
   (b) Acute respiratory, "influenzal", or "pneumonic" form;
   (c) Either of above types associated with erythema nodosum, or multiforme (known as "San Joaquin fever", "Valley fever", "desert fever" or "desert rheumatism");
   (d) Pulmonary cavity form.
2. Progressive, "secondary", disseminated infection (usually fatal, known as coccidioidal granuloma, chronic granulomatous coccidioidomycosis, "San Joaquin Valley disease", or "California disease").

Smith further states that the respiratory tract is the only significant portal of entry, but that: "Occasional infections have been credited to abrasions". Perhaps one infection in 500 or 1,000 develops into the disseminated form. When this does occur, the results are disastrous. Every attempt should be made to localize the disease by rest, until clinical and laboratory findings show that the infection is being well controlled.

In coccidioidomycosis, giant cells and caseation occur, not unlike those seen in tuberculosis; it can be distinguished from tuberculosis only by the finding of the double-contoured spherules. Carter states [3] that bony lesions are usually multiple, involve cancellous bone, and are frequently associated with considerable new-bone formation, as well as with destruction of bone. An individual lesion is rarely distinguishable from that of tuberculosis.[4]

REPORT OF A CASE

A twenty-two-year-old negro soldier was admitted to Torney General Hospital on May 12, 1944, for treatment of an infection of the index finger, which had persisted for five months. The patient cut his left index finger on January 1, 1944 on a jagged tin can, while doing kitchen police as a patient at a numbered General Hospital, during desert training, near Indio, California. He was receiving treat-

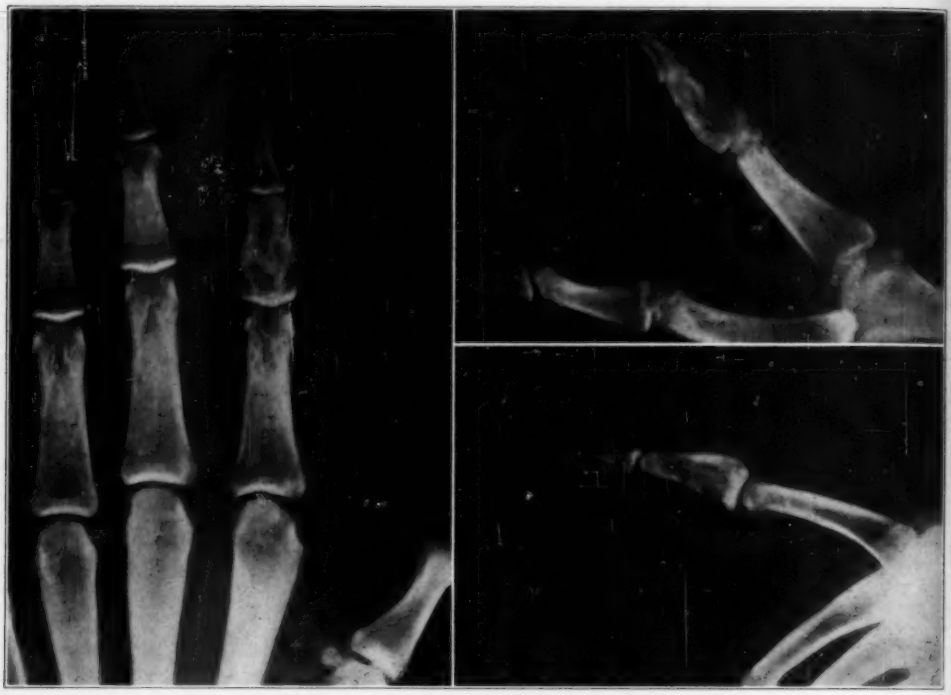

FIG. 1

Roentgenogram of left index finger, taken June 3, 1944. (*U. S. Army Signal Corps.*)

ment for infectious jaundice at that time. The finger became swollen and stiff. The patient was treated with saline soaks for several weeks, and, after the swelling had partially subsided, was discharged to continue his duties as a driver of a weapons carrier. Some swelling and stiffness in the index finger persisted, and about May 1, 1944, the skin on the dorsum of the middle phalanx broke open, and a purulent material was discharged. The patient was then sent to the Hospital.

Examination upon admission to Torney General Hospital revealed a well-developed male negro, who was five feet, ten inches in height, and weighed 155 pounds. The examination by systems was negative for abnormalities, except for the left index finger. This revealed a swollen middle phalanx with brawny induration, and a small two-millimeter sinus on the dorsum, which was discharging a thin, purulent material. The joint movements in this finger were normal and painless. Cultures were taken from the draining sinus, and were reported as hemolytic *Staphylococcus aureus* and *Staphylococcus albus*. Cultures for fungi showed a Microsporon, which was not further identified.

The roentgenographic examination (Fig. 1) revealed a localized destruction of cortex, and invasion of the medulla of the middle phalanx of the left index finger, with very little osseous regeneration. The epiphyseal ends of the bone were free from involvement.

For four weeks sulfonamides were given orally, and hot wet dressings were applied to the finger, without improvement. On June 9, a plastic amputation of the index finger, through the head of the proximal phalanx, was performed under ether, nitrous oxide, and oxygen anaesthesia. The uninvolved volar skin over the middle phalanx was utilized as a long flap to close the end of the amputation stump. The sutures were removed after twelve days, and the wound healed by first intention. The patient was given active physiotherapy for the finger, and was discharged to duty on July 22, 1944, after a program of thorough reconditioning.

Specimen No. 1326 was sent to the Army Medical Museum, Washington, D. C., for examination. The pathological report of Lieutenant Colonel Hans F. Smetana was as follows:

"*Gross Specimen*: The specimen consists of two distal phalanges of the left index finger, measuring 5 by 2 by 1.5 centimeters. The finger is swollen. On the dorsal surface, there is an ulceration measuring one centimeter in diameter, whose edges are indurated. The center shows granulation tissue, and a small amount of yellowish-white purulent material. The nail is intact. The skin of the volar surface of the medial phalanx is missing.

"*Microscopic Specimen, Section A*: This section shows a sinus tract which leads through an ulceration of the surface epithelium into the corium and subcutis. The squamous epithelium at the margin of the fistula is irregularly thickened and its rete pegs extend into the corium. The sinus tract is lined

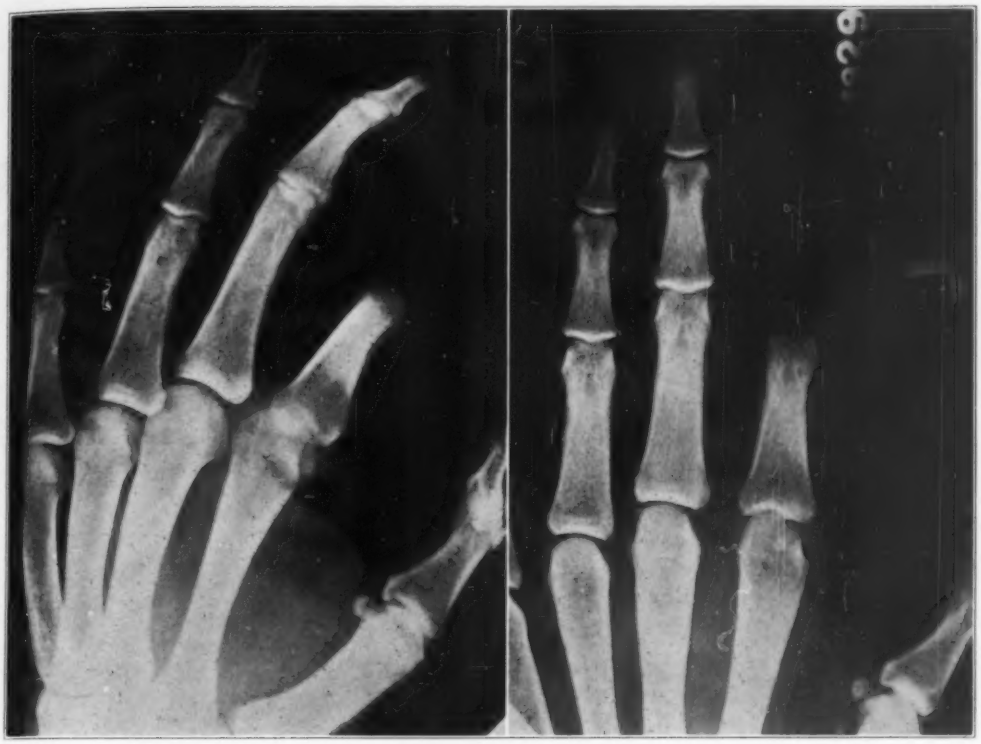

FIG. 2

Amputation stump, two weeks after operation. (*U. S. Army Signal Corps.*)

by a granulation tissue which is infiltrated with lymphocytes, plasma cells, eosinophils, and a few polymorphonuclear leukocytes. In the granulation tissue are seen tubercles, which are composed of epithelioid cells and giant cells of the Langhans type. There is no caseation. Branches of the sinus tract run perpendicular to the main course. One of these branches appears to contain caseous material, and it is lined by numerous small tubercles. In another area, solitary and conglomerate tubercles are scattered through the corium and through papillary bodies. Accumulations of polymorphonuclear leukocytes are encountered in some places. Infiltrations, composed of lymphocytes and plasma cells, have occurred in several situations in the corium, and in the subcutis, and are sometimes quite conspicuous about vessels and skin appendages in the deeper layers of the corium. A medium-sized vein in the wall of the sinus tract shows complete obliteration of its lumen by fibrous tissue of the thickened wall. Within the tubercles are seen very occasional spherical bodies with a double-contour membrane; their shells are sometimes indented. No contents of these bodies can be made out.

"*T. B. Stains*: No acid-fast organisms are seen.

"*Section B*: Except for mild lymphocytic infiltrations in the corium, there are no pathological changes.

"*Section C*: This represents a cross section through the second phalanx of the index finger. The skin surface shows an ulceration leading to a sinus tract, which reaches the periosteum of the middle bony phalanx. The entrance to the sinus tract is lined by squamous epithelium, continuous with that of the epidermis. The tract itself is lined by granulation tissue, and contains fibrinopurulent exudate. In this exudate are seen several spherical bodies, which are surrounded by a colorless hyaline, double-contoured membrane, and contain a bluish granular material, and vacuoles. Within the bone marrow there is a large area which is composed of tubercles, made up of epithelioid cells and Langhans' giant cells. The center of this area shows necrosis, resembling caseation. Within this material, as well as within some of the giant cells, are again seen spherical bodies with a double-contoured refractive membrane containing bluish granular material. The remaining portion of the bone marrow of the phalanx is mainly fibrous in character, and contains but a few islands of hematopoietic cells. There is moderate activity of osteoblasts in some places, and osteoclasts are occasionally seen in lacunae.

"*Section D*: It represents a longitudinal section through the two terminal phalanges. The skin surface is intact. In the subcutis of the dorsal aspect is seen an area of necrosis, surrounded by tubercles and granulation tissue. No spherical bodies are, however, encountered in this region. Within the bone

marrow are several conglomerate tubercles, composed of epithelioid cells and Langhans' giant cells. The central portion shows necrosis. Several spherical bodies with a double-contoured membrane, but without bluish material in the center, are present. The remaining bone marrow is partly fibrous in character and also shows areas of serous atrophy of the fat tissue. Hematopoiesis is minimal, and there is mild activity of the osteoblasts. The joint cavity between the two phalanges appears unchanged.

"*Note*: The non-budding spherical bodies in the exudate are compatible with spherules found in coccidioidal granuloma. The circumstances of the infection, however, are unusual in that it seems to have occurred after injury of the finger due to handling of a tin can. Since there is no other demonstrable localization of coccidioidomycosis, the case is interpreted as primary coccidioidomycosis of the finger, secondary to a superficial cut or abrasion, and progressing to the deeper tissues, and into the bone marrow, with fistula formation."

After the pathological examination disclosed *Coccidioides* in the tissues, a coccidioidin skin test and complement-fixation test were done. These tests were found to be positive.

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BILATERAL SIMULTANEOUS DISLOCATION OF THE SHOULDERS

Report of a Case

BY CAPTAIN THEODORE A. LYNN, *Medical Corps, Army of the United States*
AND COLONEL LEONARD T. PETERSON, *Medical Corps, United States Army*

Simultaneous bilateral dislocation of the shoulder joints is rarely seen. Only seven such cases have been reported since 1930, and information on one other case was gained by personal communication. In 1929, Dreyer reported fifty-seven cases, including one of his own, gleaned from the world's literature from 1846 to 1927. This makes a total of only sixty-five known cases in nearly one hundred years. Most of these patients have had acute dislocations, which were reduced within a short time after the injury. At least nine of the reported cases occurred during some kind of convulsive seizure. The remainder were the result of ordinary traumatic incidents. Coover's case was not recognized early, and reduction could not be accomplished by conservative methods. Open replacement was not considered, because of the patient's age and physical condition. By means of traction and manipulation under anaesthesia, Leadbetter was able to reduce bilateral dislocations which had been present for one month in a muscular negro male, and he obtained a good functional result.

The following patient, who was seen more than two months after his injury occurred, required open reduction and repair of both shoulders to obtain a satisfactory result. The authors know of no other case treated in this manner after such an interval.

CASE REPORT

A navigator of a medium bomber, aged twenty-five, sustained subcoracoid dislocations of both shoulders when his airplane crashed in a remote overseas region on April 18, 1942. He was propelled forward between the seats of the pilot and the copilot, and his shoulders were driven hard against the

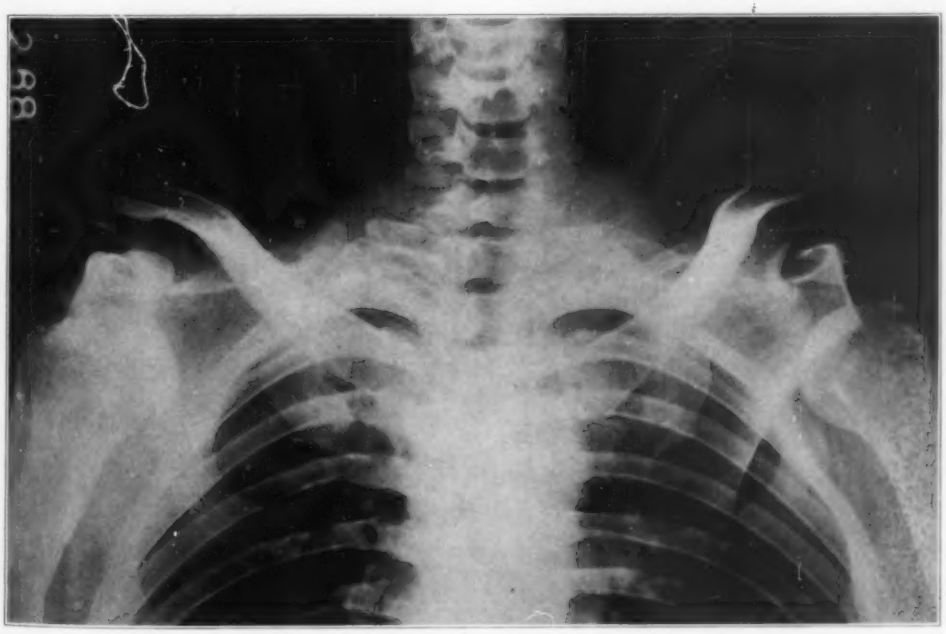

FIG. 1

Roentgenogram made eight weeks after injury. Note dense soft-tissue calcification lateral to upper humeral shaft on right.

FIG. 2

FIG. 3

Photographs eight weeks after injury, showing typical symmetrical deformity of shoulders. No voluntary motion was possible.

seat backs, as the plane struck the water and overturned. No treatment other than first aid was available until June 16, 1942, when the patient arrived in the United States and was admitted to Walter Reed General Hospital. Since the muscles of both shoulder regions had undergone marked atrophy, the diagnosis of bilateral dislocation was readily made on clinical examination. The roentgenograms (Fig. 1) confirmed the presence of subcoracoid dislocation of both shoulders, fracture of the left greater tuberosity, and calcification in the torn shoulder-joint capsule on the right. There was some atrophy of the intrinsic hand muscles innervated by the ulnar nerve on the left, and minimal ulnar hypaesthesia was present. At the time of admission, there was no axillary nerve paralysis, nor other nerve or vascular injury.

In view of the long duration of the dislocations, which resulted in bone atrophy and contraction of soft tissues, reduction by closed manipulation was not attempted. On June 19, open reduction, together

FIG. 4

FIG. 5

FIG. 6

FIG. 7

Roentgenograms of shoulders at rest, and at limits of abduction, two years and nine months after open reduction and the Nicola operation had been performed.

FIG. 8

FIG. 9

Photographs two years and nine months after surgical treatment of shoulders, showing range of active abduction. Note excellent development of deltoid muscles.

with repair by the Nicola method, was done on the right shoulder, and on July 7 a similar procedure was done on the left shoulder. The shoulders were immobilized for one month after the second operation, and then active motion was started. By January 1943 the patient had obtained fair motion in both shoulders, but was moderately restricted in rotation and abduction; he had no pain. All evidence of ulnar nerve damage had disappeared. He was discharged to limited duty in February 1943.

The patient was readmitted to the Hospital in February 1945, after he had completed two years of flight duty, as an instructor in aircraft navigation, without serious difficulty. The range of motion was improved. Abduction and flexion up to 90 degrees were possible bilaterally (Figs. 4 to 7). There was moderate restriction of rotation, and some pain in both shoulders on vigorous motion. The patient had exercised faithfully, had excellent muscle power and development (Figs. 8 and 9), and was well satisfied with the results obtained.

It was thought that the left shoulder was the easier to treat from a technical standpoint. This is attributed to the fact that the patient had had traction applied to that shoulder for a period of eighteen days prior to operation, whereas no traction had been applied to the right shoulder. The traction served to promote relaxation of the joint capsule and surrounding structures, and thus facilitated open treatment.

Delayed treatment in this case was not a matter of choice, but occurred because no adequate facilities for treatment were available for the two-month period during which the shoulders remained dislocated. It would be preferable, of course, to accomplish reduction soon after occurrence of the injury.

Prolonged physical therapy in the form of active exercise is essential, if good results are to be obtained following late open reduction of shoulder dislocation.

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AN APPLIANCE FOR THE CONSERVATIVE TREATMENT OF ACROMIOCLAVICULAR DISLOCATION

BY MAJOR MURRAY E. GIBBENS
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Most acromioclavicular separations will heal without deformity or disability, if the dislocation is reduced and is held in place for six weeks. Failures are usually due to interrupted or to inefficient fixation. There have been many methods of treating this condition. The quickest and easiest method of fixation is a Velpeau type of adhesive strapping, with a felt pressure pad over the olecranon process and another over the outer end of the clavicle. Adhesive strapping, however, has its limitations. It stretches, slips, and "gives" after four or five days, and, even though reinforced, becomes loose and uncomfortable. It often irritates the skin, and does not adhere well in hot weather. Taping is an excellent emergency procedure for a few days, but it must be replaced by a more efficient fixation.

The recent literature has contained descriptions of a number of devices, consisting of rather bulky casts, straps, or a combination of the two. Straps alone have a tendency to slip off the shoulder or elbow, and fixation is not constant. A body cast is uncomfortable, hot, and unnecessary.

The light arm "compression-cast", used by the author, has two extension bars, one in front and one in back, and an adjustable rubber elastic strap over the shoulder and the outer end of the clavicle. This has been employed on approximately ten or twelve patients, including one female patient, over a period of several years. (It is impossible to apply adhesive strapping to a woman with well-developed breasts.) The cast is well tolerated by the patients. It is light and comfortable, and permits a small amount of active motion in the shoulder without interruption of fixation. It provides a constant downward pull on the outer end of the clavicle, and an upward pull on the elbow and arm. It is easily constructed by any skillful plaster technician.

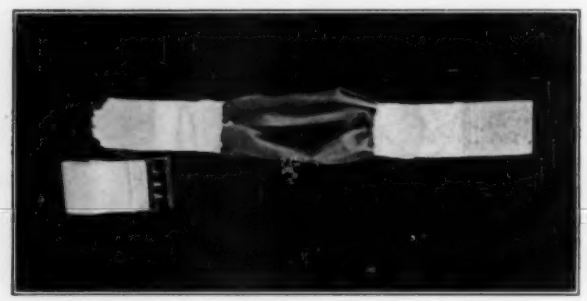

FIG. 1

Shoulder strap, composed of webbing, one and one-half inches wide, and section of rubber glove.

The strap with rubber elastic (Fig. 1) is previously prepared to go over the shoulder. A loop is made in the ends of the strap to fit over the extension bars. The rubber elastic may be a folded section of rubber glove, from which the fingers have been removed, a section of inner tube, or an Esmarch bandage. This elastic material is treated with rubber cement, sewed to the straps, and then wrapped with adhesive tape. A buckle is attached. Several of these elastic straps, with buckles and loops, may be kept in reserve.

Stockinette is used over the arm, and may or may not include the wrist and hand. The wrist is padded with sheet cotton. A felt pad is placed beneath the elbow, and another inside the arm, just below the axilla.

To make the extension bars, two aluminum strips, approximately three-quarters of an inch wide and eight inches long, are prepared and bent into hockey-stick form. About eight wooden tongue depressors are soaked in plaster until pliable. Later, these tongue depressors are bent and are used to reinforce the aluminum strips, being fastened in place with a roll of plaster.

A cast is now applied to the arm, extending as high up under the axilla as possible.

FIG. 2-A

FIG. 2-B

FIG. 2-C

Views of completed cast.

The ends of the stockinette are turned down over the plaster and sealed with plaster. When the cast is sufficiently strong, and has begun to set, the extension bars are completed and attached with plaster bandage. The elastic strap is attached to the extension bars, and adjusted loosely over the shoulder. A felt pad, four inches square, is used over the outer end of the clavicle beneath the strap to prevent chafing and pressure sores.

Figures 2-A, 2-B, and 2-C show the completed cast. The patient is advised to go to bed and lie on his side until the cast is dry. When dry, the elastic strap is tightened with the buckle. The tightness of the strap and the reduction of the dislocation are checked by palpation with the finger tip, and confirmed by roentgenogram.

The patient is advised to exercise the hand, and is encouraged to move the shoulder through a small range of abduction daily (approximately 5 to 10 degrees). The cast is removed in six weeks, and active motion of the shoulder is started.

This treatment is equally effective for fixation of fractures of the distal end of the clavicle with downward displacement of the outer fragment, preferably after manipulative reduction has been accomplished under anaesthesia.

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MODIFICATION OF CALOT PLASTER JACKET FOR IMMOBILIZATION OF THE CERVICAL SPINE

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The author has observed for several years * that the Calot jacket, when applied to correct abnormalities of the cervical spine, does not adequately immobilize the head and neck. Within a week the head and neck usually have range of motion, and the desired position of hyperextension is no longer maintained. There are several other undesirable features: The patient is unable to shave; food and liquids may easily be spilled on that portion of the cast which covers the chin; and proper oral hygiene is impossible. These factors cause irritation of the underlying skin, and discomfort to the patient.

About ten years ago the author modified the Calot jacket so as to leave the lower face and neck completely free. The principal modifications were as follows: The cast was extended across the forehead; two half-inch leather straps were included in the forehead piece; the cast was trimmed differently; and a special chin strap was added to anchor the head firmly.

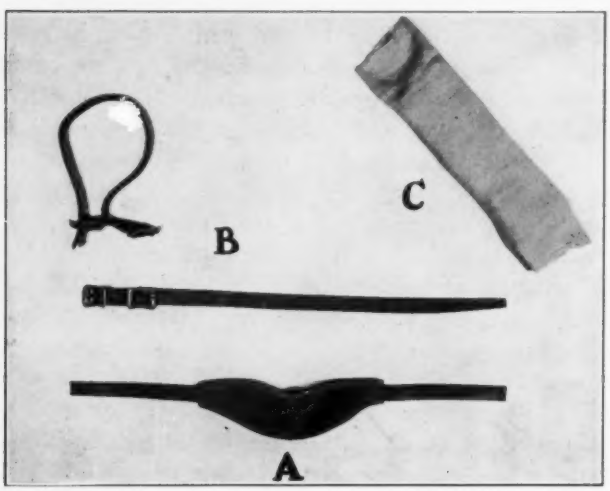

FIG. 1

Supplementary items used in modified Calot jacket.
A: Chin piece.
B: Straps.
C: Felt enclosed in stockinette.
(Photograph by Public Relations Office, Foster General Hospital, Jackson, Mississippi.)

The two leather straps have double buckles, and are eleven inches long and one-half inch wide. The buckles, each one-half inch wide, are placed, one at the end of the strap, and the other one and one-half inches proximal to the end. The strap is doubled back on itself, and the three layers between the two buckles are riveted or sewed together.

The chin strap is similar to the chin piece of a Sayre head traction strap, and may be made of leather or canvas, or of a plastic material lined with leather. A half-inch strap six inches long, with holes punched at half-inch intervals, is sewed to each corner.

The cast is applied with the patient on an Albee or Hawley fracture table. If a fracture table is not available, a piece of board three inches wide, and of sufficient length to reach the seventh cervical vertebra, can be nailed to a wooden table. The hair on the head is clipped closely. The patient's head, neck, and body to a point below the hips are then covered with stockinette, since very little padding is used under the cast. The stockinette covering the body is split at the level of the armpits, and fastened across each shoulder with several strips of adhesive tape. A piece of six-inch stockinette is then pulled over the head and neck, slit to fit the contour of the neck, and fastened with adhesive tape, at shoulder level, to the stockinette covering the body. A hole is cut in the nasal region to facilitate breathing.

Next a piece of soft felt, one-half inch thick, is placed over the region of the occiput, the shoulders, and the crest of each ilium. With the patient supine, an assistant holds the

* In civilian practice.

FIG. 2-A

FIG. 2-B

Application of modified Calot jacket. (Photographs by Public Relations Office, Foster General Hospital, Jackson, Mississippi.)

head and neck in hyperextension while applying continual traction by means of a flannel bandage around the chin under the stockinette. A piece of soft felt, one-half inch in thickness, three inches wide, and six inches long, enclosed in three-inch stockinette, is placed across the lower chin and the anterior cervical region.

The Calot cast is then applied in the routine manner, except for the following modifications:

First, a three-inch width of plaster is brought to the level of the eyebrows. After several turns of plaster have been made, the leather straps previously described are placed vertically on each side, just anterior to the ear. The ears are well padded. The end buckle is placed directly below the edge of the plaster covering the forehead, and the straps are left unbuckled. Several additional turns of plaster are applied, so as to cover the straps but not the buckles. The strap is then placed through the second buckle encircling the forehead piece. The strap is now firmly incorporated in the head piece with plaster, leaving only the end buckles exposed.

Second, it is essential that the head piece be firmly attached to the body of the cast with plaster splints, since that is the weak spot. When the plaster has set, the excess plaster over the vertex is removed, and the forehead piece is trimmed so that its lower edge is exactly level with the eyebrows. The portion covering the chin is trimmed sufficiently to allow withdrawal of the piece of felt incorporated in the stockinette. This permits adequate room for swallowing, as well as for the application of the chin strap. The remainder of the plaster over the chin and neck anteriorly can be completely removed after several days, when the cast has set. The plaster over the ears is not trimmed until the following day, to ensure maintenance of cast strength. The body portion of the cast can be trimmed immediately (Figs. 2-A and 2-B). The chin support is now fixed in position by inserting the straps at either end through the buckles in the forehead piece. The straps are pulled tight enough to keep the eyebrows level with the lower edge of the forehead part of the cast. This level is the guide at all times as to whether or not the head is properly fixed.

When the cast has been completed and the patient has returned to bed, a pillow should be placed under his shoulders so that the back of the head does not touch the bed until the cast has thoroughly dried. If this precaution is not taken, the cast may break in the region of the neck. The patient may be ambulatory in this type of cast.

This cast has been employed in cases of fracture and fracture-dislocation of the cervical spine, and in cervical osteomyelitis. It does away with the difficulties associated with shaving, feeding, and oral hygiene. During these procedures the chin piece is removed temporarily, the plaster-of-Paris band around the forehead adequately maintaining hyperextension of the cervical spine.

A UNIVERSAL SPLINT FOR DEFORMITIES OF THE HAND

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The introduction of adequate apparatus to correct the deformities caused by nerve injuries was an innovation of World War I. The problems presented by nerve injuries in the present conflict have changed very slightly from those of the preceding War. Earlier diagnosis and exploration, as well as speedier transportation to Special Treatment Centres, may have resulted in few severely contracted, withered extremities. This has decreased the need for drastic corrective apparatus, but has not altered the susceptibility of paralyzed muscles to overstretching. Early application of splints has stressed the necessity for comfortable devices that may be worn for long periods, and yet preserve the function and mobility of the uninjured parts.

There is a fundamental need for apparatus that corrects and controls the classic deformities of individual nerve paralyses. In the past this has been recognized and, as a rule, the splints produced dealt with one deformity and one degree of severity of this deformity. Apparatus that can easily be adjusted and altered to meet individual variations in type and severity will be of value.

The correction of combinations of nerve deformities and injuries to nerve vessels presents a problem which is also best met by adaptable apparatus. Similarly, the frequent association of injury to bone and to soft tissue alters the usual deformities of nerve damage.

Individual variations in skeletal and muscular structure make it desirable that an appliance be especially constructed for each patient. Such a need is obviously difficult to fulfill, and can best be met by using a standard framework, to which adjustable parts are added.

Immediately following injury, and during transport to Special Treatment Centres, the treatment of injuries to bone and soft tissue is paramount, and is best accomplished by plaster. Serious contractures often result, however, when associated nerve deformities are similarly treated. The nerve deformity is better controlled by apparatus that preserves mobility and can be incorporated in the plaster.

When physical and clinical requirements have been met, attention should be given to practical considerations, such as ease of application, inconspicuousness, and weight. The design should be simple enough to permit quantity production.

The cardinal principles of mechanotherapy are to maintain the paralyzed part in relaxation, to avoid immobilization, to prevent overstretching, and to eliminate pressure on areas which are anaesthetic or devitalized. In the hand, the unequal balance of the flexor and extensor muscles is a constant threat of deformity. Extension at the metacarpophalangeal joint is strongly produced by the common extensor and weakly opposed by the interossei and lumbricales. Flexion at the interphalangeal joints is strongly produced by the superficial and deep flexors, and is also weakly opposed by the interossei and lumbricales. The resulting tendency to metacarpophalangeal hyperextension and interphalangeal hyperflexion may best be avoided by maintaining gentle flexion at all three joints.

DESCRIPTION OF SPLINT

To meet the above considerations, a splint has been designed with a universal chassis, or holder, to which accessories may be added that will correct most hand deformities. The splint includes features of the original spring appliance of Henry Meige, and uses an improved spring similar to that suggested by Thomas. The main interchangeable parts

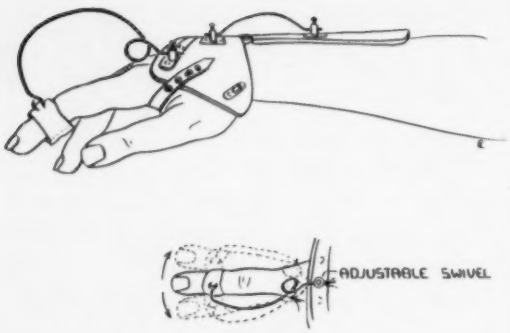

FIG. 1

Universal splint with posterior springs. Note that the leather rings support the fingers proximal to the distal joint.

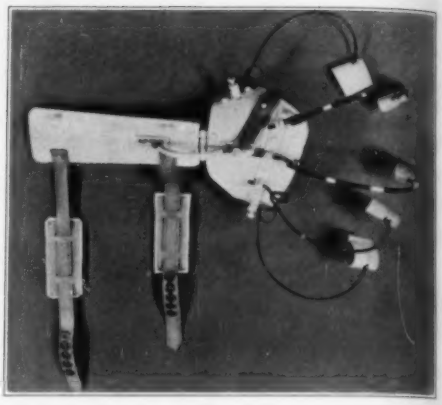

FIG. 2

Shows the posterior springs for fingers and wrist in place. The finger springs are held in studs, allowing lateral movement.

FIG. 3

Palm support may be applied so as to leave the wrist free and allow use of the hand. Note that the individual support of the fingers preserves the normal transverse arch of the palm.

FIG. 4

Correction of medial two fingers in ulnar deformity. Leather rings support the fingers close to the tip to correct the deformity.

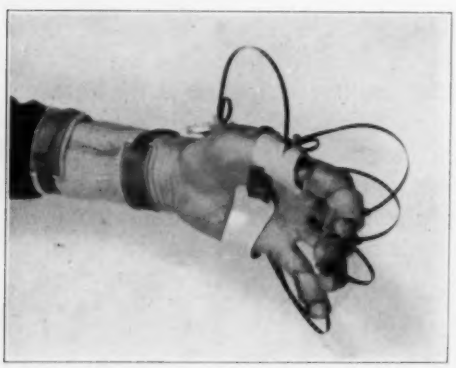

FIG. 5

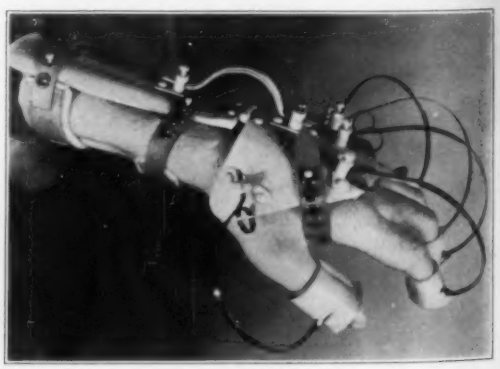

FIG. 6

The splint as applied in a paralysis of the median nerve, requiring finger and thumb correction. Note that the thumb may be pulled from position of adduction.

are steel arches, which are connected to the fingers by leather rings. They are constructed of locksmith's spring steel, 0.125 inch by 0.025 inch in size, and have a single coil at the base of the arch. The direction of the coil spring governs the axis of tension on the finger,—that is, anteriorly or posteriorly. At the same time, the direction of tension may be adjusted accurately for individual fingers by simply bending or straightening the finger arches. The temper of the locksmith's spring steel allows flexibility, and yet it will maintain the correction permanently. The spring arches are held on the chassis by studs on a fixed swivel which can be rotated, adjusting the angle between the fingers.

The chassis is made of aluminum and is easily processed; the palm is supported by a lateral tongue attached to the hand piece, which may be bent to accommodate the size of the hand.

Full wrist movement is permitted by a simple hinge, and the joint is guarded by an adjustable spring which is attached posteriorly. This spring may support the wrist in dorsiflexion, or may be reversed, maintaining volar flexion. The strength may be increased by adding one, two, or three bars, fitted into the same clamps. If no movement is desired, the spring may be locked at any desired angle. All buckle fasteners have been replaced by a simple stud-and-eye connection.

Five combinations have been most commonly used to date. The splint has been designed to be as universally flexible as possible, and there may actually be as many types as there are cases. It is expected that the surgeon in charge of each case will exercise his own ingenuity in adjusting tension, direction, and position.

1. *Posterior Splint*: The basic unit consists of a universal chassis, posterior finger springs, and a posterior wrist spring. It is used chiefly in paralyses of the radial and posterior interossei (Figs. 1, 2, and 3). It may also be adapted to the claw deformities of ulnar and median-nerve lesions. For ulnar lesions, springs are usually necessary for the medial two fingers only (Fig. 4). Slight flexion at the wrist is often necessary to relax associated contractures of the forearm. In lesions of the median nerve which need splint-

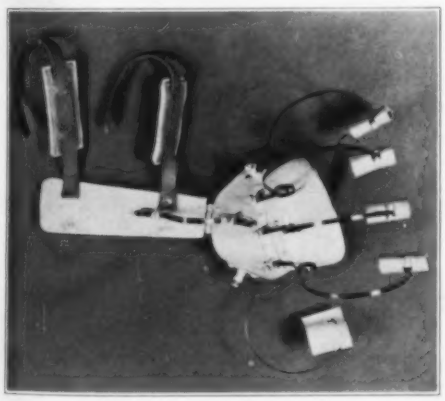

FIG. 7

Universal chassis with hyperextension guard and posterior springs.

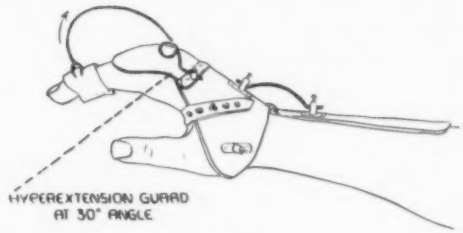

FIG. 8

Lateral diagram, showing application of hyperextension guard.

FIG. 9

FIG. 10

Anterior springs attached to the universal chassis.

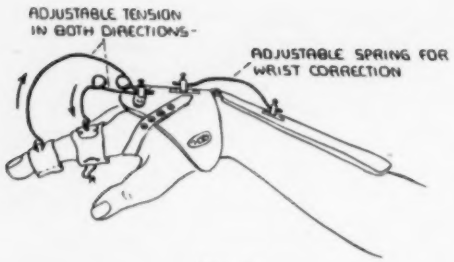

FIG. 11

Fig. 11: Shows scheme of combination springs attached to the chassis.

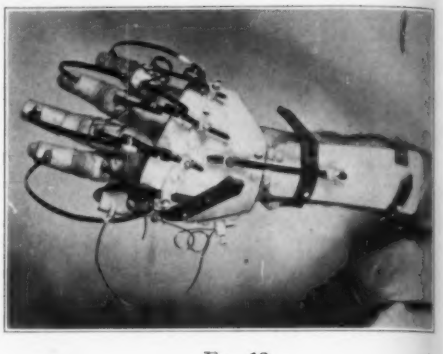

FIG. 12

Fig. 12: Combination splint, as applied to severely contracted hand.

ing, the claw deformity of the finger may be relaxed by posterior springs, and the thumb may be pulled anteriorly from its persistent adduction (Figs. 5 and 6).

2. *Posterior Splint Plus Hyperextension Guard*: In many cases, the hyperextension at the metacarpophalangeal joint must be continuously corrected to allow relaxation at the interphalangeal joints. This may be done by a fixed guard, maintaining from 20 to 30 degrees of flexion (Fig. 8). The guard may be applied for a while and removed, or it may be applied after it is apparent that adjusting the posterior arch alone is inadequate.

3. *Anterior Splint*: The splint may be converted into an anterior model by attaching springs with the coil exerting pressure anteriorly. Such a splint is most frequently needed for hands severely contracted in extension, often from plaster immobilization. The springs exert pressure through little metal cups attached to adjustable leather thongs (Figs. 9 and 10). The tension needed and the direction of application will vary for each finger, and should be adjusted by the surgeon. The continued pressure exerted by the springs tends to correct deformities fairly rapidly, thus necessitating more supervision to keep the coil spring continuously exerting maximum pressure. Associated wrist deformity may also be corrected by using anterior or posterior wrist springs, as indicated.

4. *Combination Splint*: For those cases with a severe claw deformity, injuries to the nerve vessel, and ischaemia, a combination model is available. The usual deformity of hyperextension at the metacarpophalangeal joint and hyperflexion at the distal joints is corrected by short anterior springs and long posterior springs, properly adjusted as to strength and length (Figs. 11, 12, and 13). The wrist correction may be done concomitantly. In applying this model, the fingers are put through the short springs first and then through the long holders, as in putting on a glove. Any tendency to wrinkling of the skin over the proximal interphalangeal joint may be corrected by adjusting the size of the leather holders. The tension exerted by the coil springs will need to be adjusted as the deformity is gradually corrected.

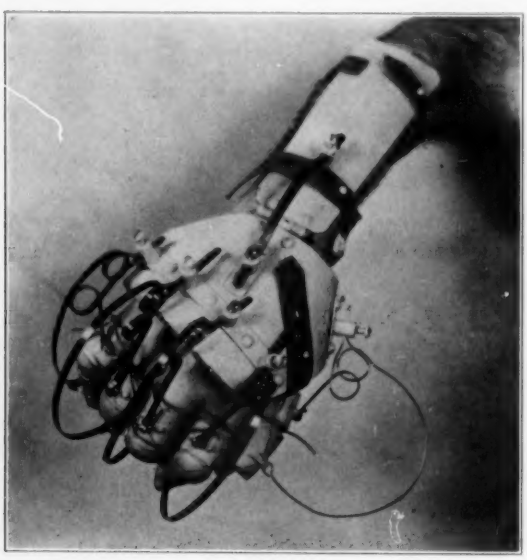

FIG. 13

Demonstrates range of movement still possible.

5. *Plaster Accessory*: Plaster immobilization of many nerve injuries has been

FIG. 14

FIG. 15

Fig. 14: Accessory stud holder in place in plaster cast.

Fig. 15: Posterior springs applied, supporting fingers in slight flexion in fractured shaft of humerus with paralysis of the radial nerve.

used as a method of splinting, frequently leading to severely contractured, almost irreparable injuries of the extremities. To enable adequate relaxation and to retain mobility, a plaster accessory is used (Figs. 14 and 15). It consists of the stud holder of the universal chassis, which may be attached and incorporated in any cast. Suitable springs may then be inserted in the usual manner.

As in the use of all corrective apparatus, there are certain precautions to be taken.

1. To be certain that the springs exert the proper tension, the splint should be adjusted by the surgeon in all cases.

2. Hyperextension at the metacarpophalangeal joint must be guarded against, particularly in weak hands. This may always be prevented by properly adjusting the spring arch or by using the hyperextension guard.

3. In all cases, the fingers and wrist should be put through a full range of movement at least twice daily.

RESULTS AND CONCLUSIONS

Approximately 400 patients with deformities resulting from injuries to nerves, nerve vessels, and associated soft tissues have been treated by various models of this splint. The splint has adequately fulfilled all the primary purposes for which it was designed. Patients have been able to wear the splint and yet use the hand for ordinary activities, such as writing, eating, and playing the piano. The constant tension which can be exerted by the spring steel has proved the most satisfactory means of correcting severe contractures, previously treated by the cumbersome banjo splint. The plaster accessory has proved a safe and adequate method of splinting, while avoiding the disadvantages of immobilization in cases requiring plaster casts. The splint has been further adapted to correct toe deformities, including drop-toe and claw-toe. The use of a universal model with interchangeable parts has facilitated production and distribution.

AN IMPROVED BONE CLAMP AND A PLATE FOR INTERNAL FIXATION OF FRACTURES

BY JEAN VERBRUGGE, M.D., ANTWERP, BELGIUM

The bone clamp devised by the author (Fig. 1) has the following characteristics and advantages: It is made of stainless steel. At one end there is a ratchet and narrow teeth, which permits a wide range of motion. The shaft has sufficient elasticity to make possible its manipulation with two fingers only. The distal end is slightly curved, so as to facilitate the handling of the instrument and yet not interfere with subsequent drilling or

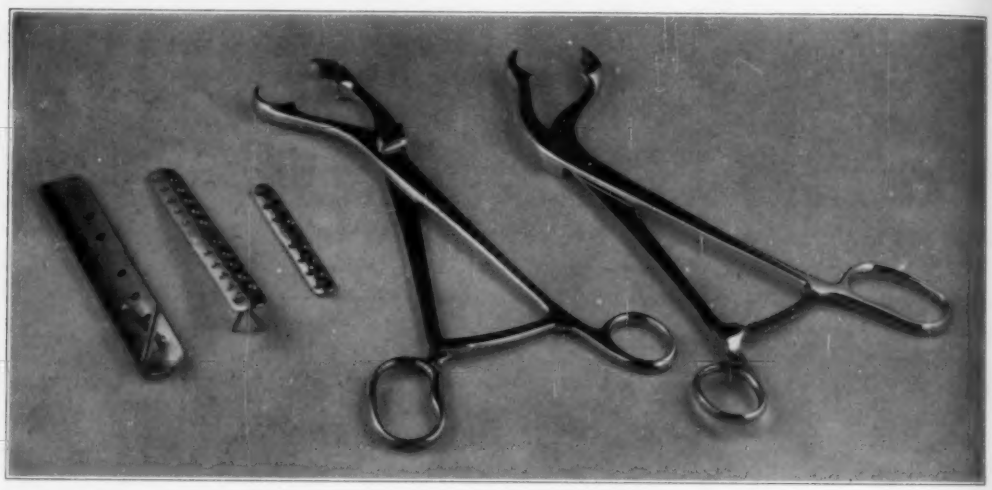

FIG. 1

Plates for fixation of femur, humerus, and bones of forearm or clavicle, showing the arrangement of screws; and bone clamp, shown from both sides.

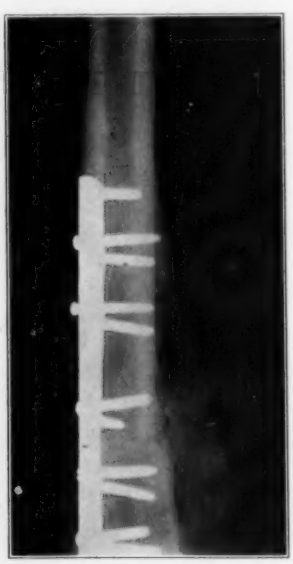

FIG. 2

Fig. 2. Plating of a femur for shortening of the lower limb (twelve centimeters). Note that all the screws are of the same length.

screwing. The clamp can be operated with one hand like a Kocher clamp, which facilitates the prehension of bone and helps in the fixation of a plate or a graft on the shaft. The bone clamp is made in three sizes—one for the femur, one for the humerus, and one for the bones of the forearm or the clavicle.

The plate was devised to ensure solid and durable fixation of bony reduction, and was constructed to meet the following requirements:

The plate should be thick in order not to bend. It should be long enough to extend well beyond the site of fracture, since the bone is more demineralized at the end of the fragments. It should be large enough to be solid and not to require the use of a second plate. It should be slightly curved transversely to approximate the shape of the bone. The holes should be placed alternately, so that the screws will be directed at an angle and not parallel to one another. The screws must not be large, so that as many as possible may be used to increase the surface of contact between metal and bone. The plate should be made of a metal which will be inert and at

the same time will bend without breaking, so as to be adjusted to the surface of the bone at the time of operation.

The following dimensions have been adopted for the plate: For the femur, twelve, fourteen, sixteen, eighteen, twenty, and twenty-two centimeters in length; two millimeters in thickness; and twenty-one and one-half millimeters in width. For the humerus, ten, twelve, and fourteen centimeters in length; two millimeters in thickness; and fifteen millimeters in width. For the forearm, four, five, six, eight, ten, twelve, and fourteen centimeters in length; one and one-half millimeters in thickness; and ten millimeters in width.

The dimensions of the screws are as follows: For the femur, two and one-half millimeters in diameter and from twenty-six to forty millimeters in length. For the humerus and forearm, two and one-half millimeters in diameter and from ten to thirty millimeters in length.

The plate and screws were devised in 1943 and the bone clamp in 1944, and the author has used them since then, without any inconvenience.

A SIMPLE TRACTION DEVICE FOR THE REDUCTION OF FRACTURES OF THE FOREARM

BY ROBERT M. ROSE, M.D., NEW ORLEANS, LOUISIANA

From the Tulane Orthopaedic Service, Charity Hospital of Louisiana at New Orleans*

The fundamental principle of traction and countertraction in the reduction of fractures of the forearm has been well established. Various methods have been used and described, from the manual application of traction by the surgeon, alone or assisted, to elaborate apparatus employing Japanese finger traps or wire finger baskets.[1] The device shown in Figure 1 maintains even, continuous traction during the reduction of fractures of the forearm, and it is extremely easy to construct and to use. Since its introduction in May 1942, from eighty to ninety surgeons at Charity Hospital of Louisiana have used this apparatus in reducing over 1,500 fractures of the forearm.

The device consists of two crossbars that clamp to a table top and project on one side for a distance of twelve inches. Covering the bars is a table pad. The patient is placed in the supine position; the head rests on the upper bar, with the upper arm parallel to the upper bar and about four inches from it. Over the anterior surface of the upper arm is placed a felt pad, and a three-inch gauze bandage is wrapped about the arm and the upper bar. This constitutes the fixed point of countertraction. The elbow is then bent at a right angle, and traction is applied to the thumb by means of a single loop of doubled three-inch gauze bandage, approximately three feet in length (Fig. 2). To this gauze loop is fixed a length of sash cord, which passes through the pulley attached to the under surface of the lower bar by means of a removable metal band. Weights on a holder are attached to the distal end of the sash cord, and traction is exerted on the forearm.

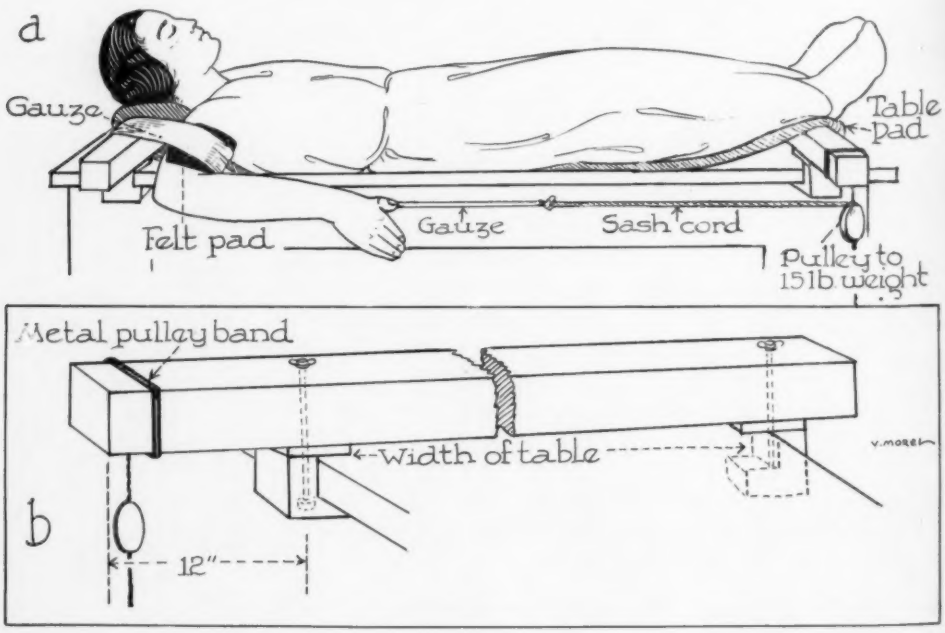

FIG. 1

a: Apparatus for reduction of Colles's fracture of right forearm. If left forearm is fractured, pulley band is placed on upper bar and patient's position is reversed.

b: Detail of construction of lower bar. Pulley band is removable, and may be placed on either bar.

* Service of Guy A. Caldwell, M.D.

There has not been a single instance of circulatory complications following the use of this device, although in a few cases it has been necessary to use twenty-five pounds of traction for thirty minutes. About 80 per cent. of the patients complain of pain in the thumb, if the fracture is reduced under local anaesthesia, but the pain disappears as soon as the traction is discontinued. Padded loops are not recommended, as they slip off the thumb.

The author believes that this device offers the following advantages:

1. The manipulative strength and sensitivity of the surgeon are not lessened by the use of his own hands for traction.

2. The device is simple and inexpensive of construction, extremely adaptable, and, if properly used, foolproof.

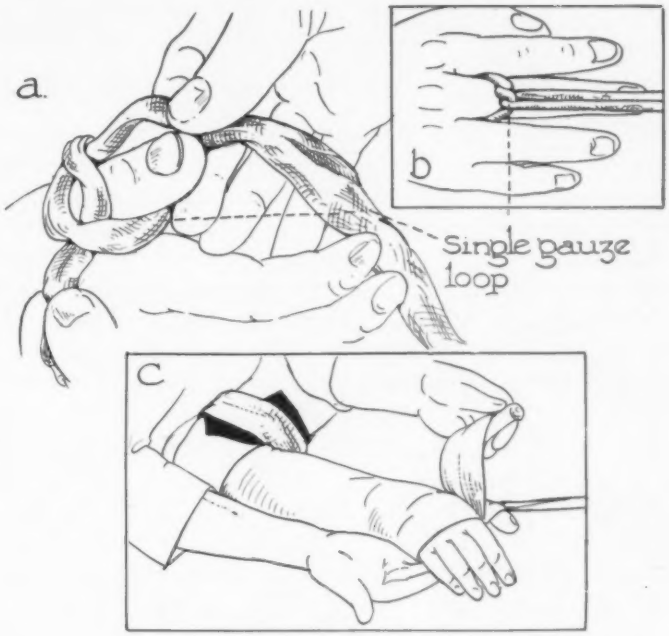

FIG. 2

a: Method of applying single-knot gauze loop about thumb for traction on forearm in functional position.

b: Gauze loop placed about long finger for traction in line with axis of both bones.

c: Illustrates ease of applying cast with traction device in place. After cast to forearm has set, arm may be removed from traction device and cast may be extended above elbow.

3. Many fractures are reduced with traction alone, although impaction of fragments is routinely broken up before traction is applied.

1. JOLDERSMA, R. D.: Traction Reduction of Fractures About the Wrist. Surg. Clin. North America, **23**: 1613–1622, 1943.

A NIGHT SPLINT FOR THE CORRECTION OF GENU VALGUM

BY H. WRIGHT SEIGER, M.D., SANTA MONICA, CALIFORNIA

The occurrence of knock-knee in children is far more common than is usually supposed. Genu valgum in children does not always disappear automatically. If, after a period of observation, it is apparent that growth and the correction of faulty foot mechanics are not sufficient to overcome the deformity, the use of braces at night may be indicated.

Lloyd [1] described a night splint, consisting of longitudinal bars bandaged to the lateral aspect of each lower extremity, for the correction of this condition. Girdlestone described a similar splint, but placed the longitudinal bars on the medial aspect of each extremity, and then bandaged both extremities together.

The splint represented in Figures 1 and 2 has the following advantages:

1. The child can sleep on his face, side, or back, instead of only on his back.
2. The construction provides more even pressure, and therefore redness at the pressure points rarely occurs.
3. Since straps and buckles are used, the mother can place the tongue of the buckle in the same hole in the strap each night, although the attending physician should see the splint about once in two weeks, in order to change the tension as the valgum lessens.
4. There is no constriction of the circulation to the extremities.
5. The average child of five years or over can be taught to apply the splint himself.

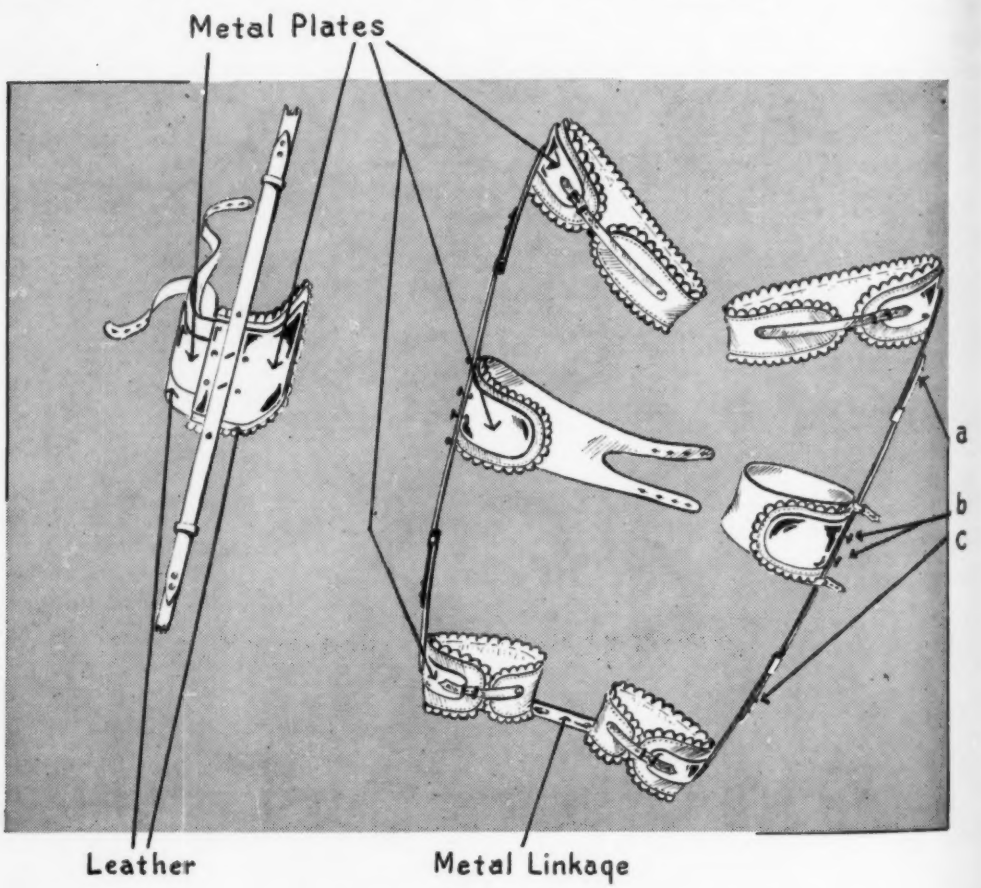

FIG. 1

a and *c*: Screws for adjustment of length of splint.
b: Screws for adjustment of height of plate over knee.

6. The splint is adjustable and can be used for children of different ages, or for the same child over a period of time. The author feels that this compensates for the fact that it is somewhat more expensive than the Lloyd or Girdlestone splints.

The average patient requires the use of this splint for about three months. Although it may be worn continually for the three-month period, it may also be worn for at least a month, discarded for an indefinite period, then worn for another month, and so on. It is not necessary to wear it tight, nor to attempt too much overcorrection at one time.

The splint may be made of steel, leather, and felt; or, to lessen the weight, may be made of duralumin with straps of felt-covered leather. To increase or decrease the lateral pull at the knees, the lateral rods may be bent slightly as the patient's condition improves.

In supervising the progress of a patient with genu valgum, it is important to keep a record of the reduction of space between the ankles. The record of the intermalleolar distance [2] was found to be a simpler, and probably more accurate, guide to the progress of each patient than the usual method of drawing an outline of the lower extremities.

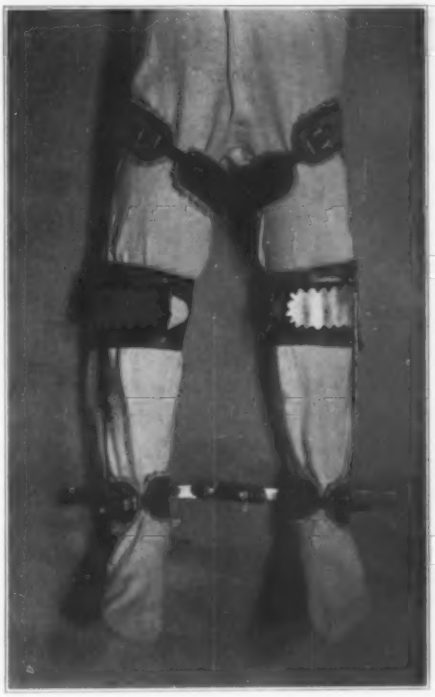

FIG. 2
The splint in position.

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1. LLOYD, E. I.: Night Splint for Knock-Knee in Children. British Med. J., **1**: 676, 1939.
2. LLOYD, E. I.: Knock-Knees and Bow-Legs. Practitioner, **150**: 238–244, 1943.
3. GIRDLESTONE, G. R.: Night Splint for Knock-Knees. Lancet, **1**: 312, 1944.

GLASS CLOTH AS A WOUND DRESSING

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The postoperative care of compound wounds, treated by the Orr method, indicates that petrolatum-impregnated gauze is not an ideal substance to use in the packing of such wounds. Changing the dressings is often quite painful to the patient because, in spite of the most careful preparation of the impregnated gauze, granulations will grow through its meshes, causing it to adhere firmly to the wounds. Unless the gauze is packed correctly, the frayed edges will cling to the wound and act as foreign bodies, causing drainage. Improperly packed gauze will act as a plug, damming back the purulent material, instead of as a means of efficient drainage. In most instances, the removal of such gauze causes considerable bleeding.

Petrolatum-impregnated gauze presents well-known difficulties in preparation, sterilization, storage, and transportation, because of the effects of temperature changes on the oil.

Consideration of these factors prompted a desire to find a dressing which would allow proper drainage and granulation of the wound so that an early split-skin graft could be applied, if desired. Such a material should have the following qualifications:

1. It should be non-irritating to the skin.
2. It should not act as a foreign body, if left embedded in human tissue.
3. It should prevent adherence of granulations.
4. It should allow proper drainage of the wound.
5. It should prevent exuberant granulation, yet allow the wound to fill in gradually by granulation, if that method of healing is desired.
6. It should not be painful to remove.
7. Its removal should not cause excessive bleeding.
8. It should be simple to use in packing wounds.
9. It should leave a clean granulating surface so that early skin-grafting may be used.
10. It should be simple to prepare by the personnel of the sterilizing room.

Glass cloth, which from previous experience in animal tissues appeared to be a possible substitute for petrolatum-impregnated gauze, has been used in thirty-five cases to date in circumstances where the gauze was previously employed.

Proper sterilization was obtained by wrapping the material in a cotton towel and placing it in the steam sterilizer for forty-five minutes at a pressure of twenty pounds.

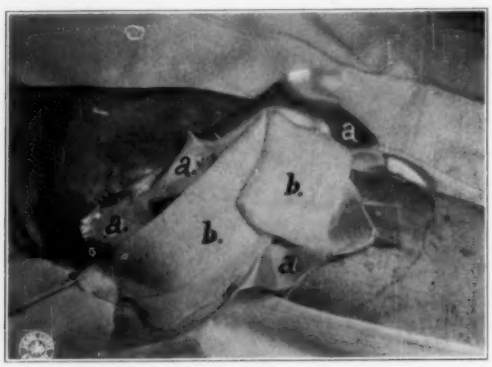

FIG. 1

Dressing applied to saucerized wound of knee. *a*: Glass cloth next to surface of wound. *b*: Dry cotton-gauze wick.

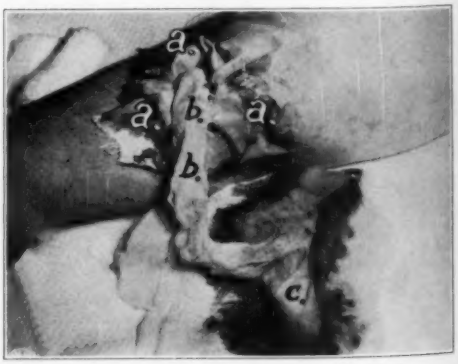

FIG. 2

Forearm wound three weeks after sequestrectomy. *a*: Glass cloth. *b*: Dry cotton-gauze wick. *c*: Exudate from wound absorbed in bulky dressing.

FIG. 3-A

FIG. 3-B

Shoulder wound, three weeks after saucerization of cavity.

Fig. 3-A: Glass cloth on wound surface; no granulations are growing through meshes.

Fig. 3-B: Glass cloth has been removed, showing clean granulations and no bleeding or thick exudate.

FIG. 4-A

FIG. 4-B

Split-skin graft, ten days after operation.

Fig. 4-A: Glass-cloth dressing forms a smooth stent.

Fig. 4-B: After removal of dressing, showing healed wound.

The material has also been prepared by boiling for ten minutes in the water sterilizer. Although either method is satisfactory, the former is preferred because the material can be stored in the same package until needed.

In applying the dressing at the time of surgery, a square of the glass cloth should be cut, large enough to cover all surfaces of the wound and to project over the skin margin. The center of the invaginated glass cloth should be packed with dry cotton gauze so that the edges of the wound will be held open (Fig. 1). The cotton gauze acts as a wick (Fig. 2) to remove exudate from the wound, and on top of this is placed more cotton gauze to take up the secretions. A pressure bandage or padded cast, as indicated, is placed over such a dressing.

This type of dressing has been left in wounds for varying lengths of time and contra-indications have not been observed. Scholz and Mountjoy[1] reported a suture of similar glass material as inert and non-reacting in tissue.

Figures 3-A and 3-B show a typical wound at the time of dressing.

Glass cloth has been used as the first layer of a wet dressing for a split-skin graft (Figs. 4-A and 4-B).

1. SCHOLZ, R. P., AND MOUNTJOY, P. S.: Fiberglas Suture Material. Preliminary Report. Am. J. Surg., 56: 619-621, 1942.

LOCALIZED BONE CYST OF THE OS CALCIS

BY SQUADRON LEADER J. M. JANES
Royal Canadian Air Force, Medical Branch

From the No. 1 Royal Canadian Air Force Hospital, St. Thomas, Ontario, Canada

The localized form of osteitis fibrosa cystica, which usually occurs during adolescence, is said to be more common than the generalized form. The common sites are the upper end of the femur, the humerus, and the tibia, although Illingworth and Dick have stated that no bone is immune.

The following case is reported because a cyst occurred in the os calcis. This is not a common site, although McLachlin has reported one such case. The case herein described is typical in that there was no disturbance of the calcium balance.

R.E.D., an airman, aged eighteen, reported on sick parade five days after spraining his left ankle. Clinically, no abnormality of the ankle was found, but the roentgenogram revealed a large cyst of the os calcis (Fig. 1). Roentgenograms of the long bones showed no evidence of other cysts.

On laboratory examination the urinalysis was negative, as was the Wassermann reaction. The erythrocyte sedimentation rate was five millimeters in one hour (method of Westergren). The serum calcium was 11.8 milligrams per 100 cubic centimeters of serum. The inorganic phosphates were 4.7 milligrams per 100 cubic centimeters.

At operation, a small window was made in the lateral aspect of the left os calcis, opening directly into the cyst. The cyst was oval in shape, roughly two inches in length, and one and one-half inches in width at its widest point. It was filled with hemorrhagic fluid which contained fat globules. Very little soft tissue was seen; the walls for the most part were smooth bone. The fluid was drained off, and the soft tissue was curetted out for pathological examination. Twenty-four bone chips from the subcutaneous surface of the left tibia, one-half inch by one-quarter inch by one-eighth inch in size, were placed in the cystic cavity, but were insufficient to fill the cavity completely. After closure a below-the-knee non-weight-bearing cast was applied.

FIG. 1
Cyst of the os calcis.

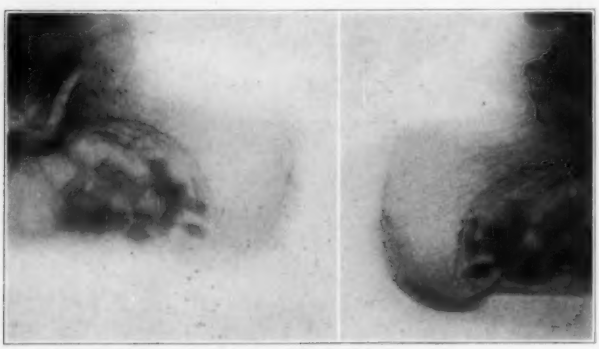

FIG. 2
Five and one-half months after operation.

The pathological report was as follows: "Part of the tissue is of bony character (the piece removed to gain access to the cavity), and the sections show some bone absorption and osteoporosis. Other parts of the specimen are composed of fibrous tissue, and throughout this tissue there are occasional multinucleated giant cells, as well as numerous small cystlike spaces, lined partially by cells which appear to be of the osteoclast type. We consider this to be osteitis fibrosa cystica."

Ten weeks after operation, a walking plaster was applied. Five and one-half months after operation, the roentgenogram showed bony consolidation of the bone chips (Fig. 2). At this time the patient walked normally and had no complaints; he was therefore discharged to duty.

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MCLACHLIN, A. D.: Treatment and Results in Localized Osteitis Fibrosa Cystica (The Solitary Bone Cyst). J. Bone and Joint Surg., **25**: 777–790, Oct. 1943.

A SIMPLE RETRACTOR FOR SPINAL SURGERY

BY G. MOSSER TAYLOR, M.D., LOS ANGELES, CALIFORNIA

From the Department of Orthopaedic Surgery, College of Medical Evangelists, Los Angeles

For many years the retractor most consistently used for spinal surgery has been the one designed by Russell Hibbs for his type of spinal arthrodesis, which requires exposure of the zygapophysial joints. Any assistant who has worked for hours with one of these retractors can testify to the fatigue that results.

A number of retractors have been advanced to simplify the work of interlaminary exploration and removal of a protruded intervertebral disc. Most of them are based upon a screw or ratchet mechanism, however, and are rather complicated.

A number of the newer retractors for general orthopaedic surgery are based upon the principle of leverage, using the bone itself as the fulcrum. The spinal retractor herein described (Fig. 1) is based upon the same idea.

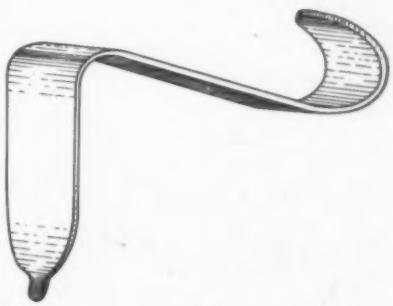

FIG. 1

The retractor is made of stainless steel, one-sixteenth of an inch in gauge and one and one-half inches wide; the handle is seven inches long, and the retracting blade is two and one-half inches long for the medium back and three and one-half inches long for the heavier backs.

The important feature of this retractor is the small tip at the end of the retracting blade. The tip is three-eighths of an inch wide and one-half inch long, and is curved slightly forward. The back surface is beveled to a dull edge at the end of the tip.

After the musculature is stripped from the spines and laminae, the lateral facet at the level needing retraction is palpated. The tip of the retractor is then caught on the lateral surface of this facet (Fig. 2), which becomes the fulcrum upon which leverage is made for the retraction of the muscles and the cutaneous tissue.

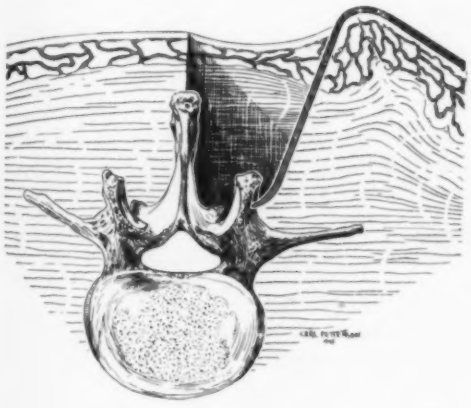

FIG. 2

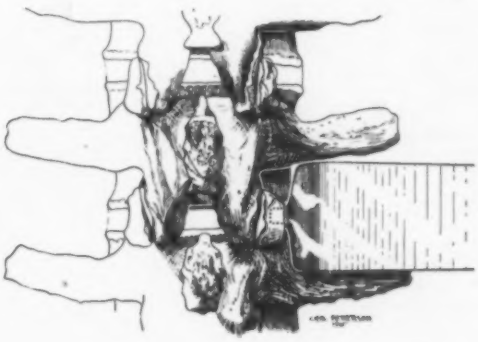

FIG. 3

The shoulders of the retracting blade are rounded from the lateral surface of the blade to the beginning of the tip, which makes the retractor more effective in the depth of the wound.

The retractor is flexible enough so that the angle between the retracting blade and the handle can be changed, depending upon the character of the back. The end of the handle is curved upward in a half circle, which makes it easy to support. In the event of incomplete assistance, a loop of sterile bandage can be slipped over the handle and the other end caught under the toe of the surgeon, making the retractor practically self-retaining.

A word of caution must be given, because the leverage exerts a powerful force. If this is maintained too strenuously and for too long a time, the soft tissues may sustain unnecessary pressure necrosis.

The retractor described has been used for the past six months by a number of local orthopaedic surgeons. From their experience, it is believed that the retractor has been of definite aid in simplifying and facilitating a strenuous surgical procedure.

D. MURRAY MEEKISON

1897–1945

D. Murray Meekison died at his home in Vancouver, British Columbia, on October 18, 1945, of coronary thrombosis. In his early death at the age of forty-eight, the Pacific Coast suffers the loss of a leading orthopaedic surgeon.

He was born in Strathroy, Ontario, and moved to British Columbia in 1910; from there he entered the War in 1916, as a private in the University Battalion. He won his commission in the field and was transferred to the Seaforth Highlanders of Canada, a famous Highland Regiment, the pride of Vancouver, which in two wars has brought distinction and fame to Canadian arms. After he graduated in medicine and returned to Vancouver to practise, he became the medical officer of the Seaforths, and remained in that position until 1939, when the regiment went into action again.

Dr. Meekison received the degree of M.B. from the University of Toronto in 1924, and was awarded his B.Sc. the following year. He received postgraduate training in the Hospital for Sick Children, Toronto, and at the Montreal General Hospital. In the Children's Hospital, Toronto, he came under the influence of W. E. Gallie and C. L. Starr, and this determined his future. When he began to practise in Vancouver, it was in the field of orthopaedic surgery, in which he rapidly forged to the front and became a leader among the young orthopaedic surgeons of the Pacific Coast, both Canadian and American. He was President of the Western Orthopaedic Association and a Past-President of the North Pacific Orthopaedic Society; a member of the British Orthopaedic Association; a Fellow of the American College of Surgeons; a Fellow of The Royal Society of Medicine, London; a Fellow of The American Academy of Orthopaedic Surgeons; and a member of The American Orthopaedic Association. At the time of his death, he was Chief of the Orthopaedic Service at St. Paul's Hospital, Vancouver; Chief of the Queen Alexandra Solarium for Crippled Children, Cobble Hill, Vancouver Island; and Chairman of the Orthopaedic Section of the Vancouver Medical Association.

In the field of industrial and traumatic surgery he had a large experience, drawn from the logging and shipbuilding industry of the West Coast. It was he who first recorded the unusual type of fracture of the patella caused when it is driven sideways across the condyles of the femur (tangential osteochondral fracture of the patella). He also had a large practice with crippled children.

Early in World War II (May, 1941) Murray Meekison joined the Royal Air Force Medical Service and became one of the senior surgeons in the highly important and efficient Orthopaedic and Rehabilitation Service organized by Sir Reginald Watson-Jones. He continued in this Service, until he was invalided home two and a half years later. His death was the direct outcome of this illness.

Life was a battle for the accomplishment of high ideals for Murray Meekison, and he shirked not one whit of it. What he attempted he undertook without stint, and he threw into his effort the immense energy of a strong nature. He inherited from covenanting Scotch ancestors a fierce intolerance of wrong, of slipshod work and thinking, and of smug self-satisfaction, which often involved him in strenuous efforts to correct them,—battles which endeared him to his friends and commanded the respect even of those who felt the force of his attack. There was a stern joy for him in attempting to set wrong right.

Though he was one of the youngest members of the Association, he had many friends among the members. The Association by his death has lost a member of sterling character, and shares with his wife and children the hard bereavement.

GUY WHITMAN LEADBETTER

1893–1945

On November 11, 1945, Dr. Guy Whitman Leadbetter, President-Elect of The American Academy of Orthopaedic Surgeons, died in the Emergency Hospital, Washington, D. C., of coronary occlusion. He had been confined to the hospital only a few days and died, as he had lived, without fear, advising his friends that he had no apprehension about his health.

To his friends and associates he typified the "Indestructible Man",—a person endowed with the physical, mental, and temperamental qualities, who should have lived to be a centenarian and not have passed at the age of fifty-one, when his many sterling qualities were being recognized and a future still lay before him. He accomplished much and America has lost one of its most brilliant orthopaedic surgeons.

It is difficult for one to portray Guy Leadbetter to those who did not know him well. Modest and retiring, but always serving with great efficiency and judgment in any task assigned him, be it a local, national, or international problem, he came through with a finished result that was typical of a great man. He had many friends from many walks of life, but only a few knew of his many interests. His church, his professional, and other friends saw only the side of his life in which they were interested.

Born in Bangor, Maine, December 12, 1893, the son of Fred H. and Maude E. Leadbetter, he enjoyed the advantages of the wholesome and rugged life of New England. He entered Bowdoin College and was graduated with an A.B. degree in 1916. In his senior year he was Captain of the Track Team, Captain of the Football Team, established the intercollegiate record for the 16-pound hammer which stood for many years, and was a candidate for the Olympic Team. He was President of his Class and was elected to the Phi Beta Kappa Society. These achievements while at college show the great physical, mental, and personal qualifications of the man. He retained his interest in his Alma Mater and was

a member of the Bowdoin Alumni Council and Chairman of Bowdoin Alumni Association, Chapter of Washington, D. C., and in 1942 was given the honorary degree of Doctor of Science.

He received his M.D. degree from the Johns Hopkins University School of Medicine in 1920. In Medical School he attained a high scholastic standing, engaged in many University and Medical School activities, and was one of the most highly regarded students in his class. While a student, he chose to become an orthopaedic surgeon and received his surgical training at the Lakeside Hospital, Cleveland, Ohio, and his orthopaedic training at the Johns Hopkins Hospital and the Children's Hospital School. He entered private practice in Washington, D. C., in 1923, and became one of the outstanding surgeons of the community and soon earned a well-deserved national and international reputation. Many contributions were the result of his work, the most notable of which was his untiring interest in fractures of the neck of the femur. He was Clinical Professor of Surgery at the George Washington Medical School, Chief of the Orthopaedic Service of the Emergency Hospital, and Consultant to the Children's Hospital and the Casualty Hospital.

His sterling qualifications were recognized early and he was elected a member of The American Orthopaedic Association in 1930 and of The American Academy of Orthopaedic Surgeons in 1934. He also served as Chairman of the Bone and Joint Section of the Southern Medical Association.

Dr. Leadbetter was a man who never shirked a responsibility. He served on the Military Committee of The American Orthopaedic Association and The American Academy of Orthopaedic Surgeons for many years and gave unstintingly of his time to the Office of the Surgeon General. He was appointed Orthopaedic Consultant to the Secretary of War, and Secretary to the Orthopaedic Committee of the National Research Council.

He was an accomplished pianist and had a fine and well-trained baritone voice. He was a linguist, and was proficient in German, Spanish, and French.

Among his other hobbies were astronomy, geology, entomology, scientific photography, anthropology, and archaeology. He gave many lectures on these subjects and compiled an illustrated lecture on "Mayan Ruins at Yucatan". For several years he was the guest lecturer on the Outdoor Program of the National Capital Parks and spoke on a wide variety of subjects, as "Death Valley Days", "Bird Life", and "With the Lumber Jacks in the Maine Woods". His interest and work in anthropology was so outstanding that several days after his demise a letter arrived, offering him a membership in the Anthropological Society at Albuquerque, New Mexico. He was a forceful speaker, and his spoken and written language were characteristic of his cultural background.

"With all of his stern appearance and serious mind, he was one of the kindest men I have ever known; we shall always miss him",—was the remark of one of his older colleagues with whom he had worked for years.

It was very fitting that such a man should have had an ideal family life. In September 1925 he married Alice Charlotte Johnson, and he is survived by her and their two children, Guy Whitman, Jr., and Patricia Alice.

EUGENIO DÍAZ LIRA

1880–1945

Eugenio Díaz Lira, Chilean surgeon and statesman, died at Santiago, Chile, on June 12, 1945, at the age of sixty-five.

Dr. Díaz Lira studied medicine at the University of Chile, specialized in child surgery and orthopaedics under Broca and Kirmisson in Paris, and then took a course in tuberculous affections at Berck-sur-Mer, under Calot and Menard. Upon returning to his native land, he became the first Professor of Orthopaedic and Infantile Surgery in the University of Chile, and a pioneer in the field.

He conducted the clinics at the Roberto del Rio Hospital for Children for forty years. He founded the Nurses' Training School, and thus pioneered in establishing this profession in Chile. Likewise, he was the founder and President of the Sociedad de Pediatria and the Society of Surgeons. In 1930 he was appointed Director of the School of Medicine of the Catholic University in Santiago. In addition to holding membership in local societies in Chile, Dr. Díaz Lira was a member of the Société Française de Pédiatrie, corresponding member of the Peruvian Society of Pediatrics, a member of the Society of Surgeons of Buenos Aires, and an honorary member of the American Academy of Orthopaedic Surgeons.

The Government of Bolivia conferred upon him the decoration of the "*Condor de los Andes*", in recognition of his services and professional aid to so many Bolivians and of his invaluable contribution to the mutual understanding of Chileans and Bolivians.

Dr. Díaz Lira is survived by his widow and several children. One son, Eugenio Díaz Bordeu, was associated with his father in the practice of orthopaedic surgery.

ANDREW PRITCHARD MacKINNON

1880–1945

On June 14, 1945, Dr. Andrew Pritchard MacKinnon died in Winnipeg after a long illness.

Dr. MacKinnon was born in North Wakefield, Quebec, but had lived in the Province of Manitoba since 1883. He was educated at Griswold, Portage la Prairie, and Winnipeg, and was graduated from Manitoba Medical College in 1907. After several years of general practice in Portage la Prairie, he went overseas with the Eleventh Canadian Field Ambulance, and returned to Canada in 1918. He worked in the Orthopaedic Wards of the Fort Osborne Military Hospital, and then spent six months in the Manitoba Sanatorium at Ninette, gaining experience in the treatment of tuberculosis. In 1920 he became associated with the late Dr. H. P. H. Galloway, and after the death of Dr. Galloway he headed the MacKinnon Clinic.

Dr. MacKinnon was a Fellow of the American College of Surgeons, a Fellow of the Royal College of Surgeons of Canada, and a Fellow of The American Academy of Orthopaedic Surgeons. He had been President of the Winnipeg Medical Society, and was chief of the Orthopaedic Service at St. Boniface Hospital and lecturer in orthopaedic surgery in the University of Manitoba.

Dr. MacKinnon was a man of the highest principles, and will long be remembered by his patients for his sincerity and his devotion to their interests. He was of kindly disposition, and his passing has left a definite gap in the medical life of Winnipeg.

News Notes

PROGRESS ON GRADUATE TRAINING IN ORTHOPAEDIC SURGERY

Since the statement on Postgraduate Training in Orthopaedic Surgery was published in the October issue of *The Journal of Bone and Joint Surgery,* events have developed so rapidly that now the need for additional residencies for training orthopaedic surgeons has become an urgent demand. Despite the increased number of approved residencies, there is a much greater need than was anticipated. Many heads of services have reported a large number of applicants. Our plan to have a registry established for orthopaedic residencies and applicants has not been realized simply because personnel could not be found to handle the work. It is hoped that within a few weeks such a registry will be established.

A good many services have not been able to execute their reorganization plans as yet, but should be ready for additional residents within the next six months. In a good many instances, residencies are being held for men who had partially completed their training before entering the Army. The uncertainty about the time of discharge for some of these men leaves some residencies unfilled at this time. Other men who have applied in advance of their release have been put off until such time as their dismissal date is known.

Additional services for training residents will be certified in the near future, and it is hoped that others will be developed in communities where the committee feels adequate facilities and personnel are available. Expansion of already existing services will be possible in some instances, but it appears that there will not be enough services to satisfy the demand.

In planning new services some lack of understanding has been evident regarding the amount of training in the basic sciences necessary to qualify for the examinations of The American Board of Orthopaedic Surgery. Much has been written and spoken about this phase of training, but it was evident that a more definite proposal was necessary to clarify the Board's position. To this end the Board prepared the following statement:

Plans for Basic Science Training

Preamble

It is fundamental that directors of hospitals and medical schools should recognize the importance of training in the basic sciences. Residents should be released from hospital duty for the time necessary to take these courses, and the medical school faculty and visiting staff should provide the necessary facilities and instructors. The Board has specified that six months, or approximately one sixth of the total three-year resident-training period, should be devoted to the basic sciences,—anatomy, pathology, physiology, and biochemistry and bacteriology. In those institutions approved for two or three years of resident training, integration of the work in the basic sciences with clinical training is desirable, *provided* the working schedules for residents are arranged to allow sufficient free time to be equivalent to six months of undivided time.

If matched training is acquired in several different institutions or in localities where adequate facilities do not exist, a minimum of six months of undivided time should be devoted to instruction in basic sciences.

During the limited time allowed, residents should study that portion of each subject related to efficient practice of orthopaedic surgery. The trainees should not be expected to become competent assistants in the departments of anatomy and pathology. On the contrary those departments should have the necessary instructors and facilities to help the trainees acquire the required knowledge.

Therefore, the suggestion is made that the basic sciences be taught primarily by members of the orthopaedic staff, with assistance from instructors of the basic sciences as indicated.

Basic Science Training

I. *Pathology*: Perhaps forty per cent. of the training period should be devoted to pathology. This should include pathology of joint diseases, bone tumors, various diseases of bone, soft-tissue tumors, and other diseases, and such general pathology as is germane to the subject.

The aim should be to establish, under supervision of the orthopaedic staff and residents, orthopaedic museums which would include gross specimens, microscopic slides illustrating the most important lesions, and case records covering the above.

II. *Anatomy*: It is felt that approximately forty per cent. of the time in basic sciences should be spent in anatomy. Cadavera, when available, moulages, and preserved specimens and skeletons should be provided for this study. Instruction in operative exposures should be

given by an orthopaedic staff member utilizing this anatomical material. Instruction should also be given in the relation of anatomy to body mechanics.

III. *Bacteriology*: Approximately ten per cent. of the time should be spent in the clinical application of bacteriology. The study of the relation of bacteriology to wound healing, the flora of wounds, gross infections, and the relation of antibodies and treatment of wounds to chemotherapy, and a review of the subject of virus diseases should be included.

IV. *Physiology and Biochemistry*: Again, we suggest that ten per cent. of the time for basic sciences be allotted to these subjects. Seminars should be conducted on shock, fluid balance, electrolytes, blood substitutes, acids, calcium and phosphorus, metabolism, and the chemistry of joint fluids.

V. Seminars or conferences are considered most suitable for the review of this subject.

From this it should be clear that the review of the basic sciences may be given in the form of a six-months' course, or it may be spread through the training program. It is suggested that the entire orthopaedic staff should take part in the training program; they themselves will benefit from such participation.

In some communities the shift of patients from hospital services and out-patient clinics to the care of private specialists has left hospital services short of material for training purposes. Anticipating such a state of affairs, last January the Board passed the following resolution:

"In special instances, with the approval of the Committee on Resident Training, the Board will recognize for not over two years' training in orthopaedic surgery periods of training in which the candidate combines work in a hospital service with part-time assistantship to an orthopaedic surgeon certified by The American Board of Orthopaedic Surgery, provided that the major part of his time is spent in the hospital service."

In order to make such a service acceptable, a description of the hospital and office services with an outline of the proposed schedule for work should be filed with the Board.

A registry has recently been established, and it is suggested that from now on all persons seeking appointments to residencies and all heads of services seeking men to fill their residencies contact Dr. A. R. Shands, Jr., Box 269, Wilmington, Delaware.

There will be a booth at the meeting of The American Academy of Orthopaedic Surgeons in January 1946, where information regarding residencies can be exchanged.

R. K. Ghormley, M.D., Chairman

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Thirteenth Annual Convention of The American Academy of Orthopaedic Surgeons will be held at the Palmer House, Chicago, January 20, 21, 22, and 23, 1946, under the presidency of Dr. E. Bishop Mumford.

Registration will begin at ten o'clock, Saturday morning, January 19. During the afternoon, motion pictures will be presented, and in the evening the Instructional Section Dinner will be served. The program for the evening will include a panel discussion of "The Painful Shoulder and Upper Extremity".

The Scientific, "New Ideas", and Technical Exhibits may be visited on any of the Convention days, and several programs of motion pictures have been planned.

The program prepared by the Sub-Committee on Instructional Courses includes a series of teaching periods, dealing with fundamental topics related to orthopaedic surgery. The regions to be covered this year are: (1) The Foot and Ankle; (2) The Knee; (3) The Hip; and (4) The Shoulder. The Courses are as follows:

COURSE I. THE FOOT AND ANKLE

Orthopaedic Anatomy of the Foot and Leg.	Theodore A. Willis, M.D.
Symptoms, Pathology, and Diagnosis.	Lenox D. Baker, M.D.
Diseases of the Foot and Ankle with Special Reference to Treatment.	J. Warren White, M.D.
Treatment of Traumatic Lesions of the Foot and Ankle.	Harry Winkler, M.D.

COURSE II. THE KNEE

Orthopaedic Anatomy of the Knee.	Allen F. Voshell, M.D.
Symptoms, Pathology, and Diagnosis.	Robert V. Funsten, M.D.
Diseases of the Knee Joint.	J. Albert Key, M.D.
The Treatment of Traumatic Lesions of the Knee Joint.	John R. Cobb, M.D.

COURSE III. THE HIP

Orthopaedic Anatomy of the Hip.	John J. Fahey, M.D.
Symptoms, Pathology, and Diagnosis.	A. Bruce Gill, M.D.
The Treatment of Diseases of the Hip Joint.	Alan DeForest Smith, M.D.
Traumatic Hip Lesions with Special Reference to Treatment.	Lawson Thornton, M.D.

COURSE IV. THE SHOULDER

Orthopaedic Anatomy of the Shoulder.	Major J. E. Milgram, M.C.
Symptoms, Pathology, and Diagnosis.	Toufick Nicola, M.D.
Treatment of Non-Traumatic Lesions of the Shoulder.	David M. Bosworth, M.D.
Treatment of Traumatic Lesions of the Shoulder Joint.	Harrison L. McLaughlin, M.D.

COURSE V. PHYSIOLOGY

Physiology of Bone in Health and Disease.	C. H. Hatcher, M.D.
The Orthopaedic Physiology of Nerves.	Edward L. Compere, M.D.
Physiology of Muscle.	Eben J. Carey, M.D.
The Normal and Pathological Anatomy and Physiology of Articular Structures.	Granville A. Bennett, M.D.

COURSE VI. ORTHOPAEDIC X-RAY

The X-Ray Investigation of Certain Orthopaedic Problems.	S. A. Morton, M.D.

COURSE VII. INFANTILE PARALYSIS

The Treatment of Anterior Poliomyelitis in the United States: History and Development.	Ralph K. Ghormley, M.D.
Present Methods of Treatment in Anterior Poliomyelitis.	William T. Green, M.D.

COURSE VIII. PRINCIPLES OF FRACTURE MANAGEMENT

Principles of Fracture Treatment.	Paul B. Magnuson, M.D.

COURSE IX. CONSERVATIVE TREATMENT OF LOW-BACK SYNDROME

The Conservative Treatment of the Low-Back and Sciatic Syndrome.	E. M. Regen, M.D.

COURSE X. CEREBRAL PALSY

Cerebral Palsy.	W. M. Phelps, M.D.

COURSE XI. POSTURE

Posture.	Captain Frederick A. Jostes, M.C.

COURSE XII. CLUB FEET

Treatment of Congenital Club-Foot.	J. H. Kite, M.D.

COURSE XIII. FRACTURES OF SHAFT OF FEMUR

Treatment of Fractures of the Shaft of the Femur.	Guy A. Caldwell, M.D.

The Monday morning session will be devoted to a Symposium on Degenerative Hip Disease:

Etiology and Pathology of Degenerative Hip Disease.	Dallas B. Phemister, M.D.
Conservative Treatment.	Paul C. Colonna, M.D.
Arthrodesis of the Hip Joint for Degenerative Hip Disease.	G. Edmund Haggart, M.D.
Arthroplasty of the Hip for Degenerative Hip Disease.	Carl E. Badgley, M.D.
Drilling Operation and Summary.	Melvin S. Henderson, M.D.

On Monday, Tuesday, and Wednesday the Scientific Program will be presented, and Academy Luncheons will be held at one o'clock on each of those days. There will be Executive Sessions at noon on Monday and on Wednesday. The following program has been announced by the Program Committee, Dr. Robert W. Johnson, Jr., Chairman:

MONDAY, JANUARY 21

Afternoon Session

Combined Neurectomy and Bone Graft in Spastic Torticollis.
Alfred W. Adson, M.D., Rochester, Minnesota.
H. Herman Young, M.D., Rochester, Minnesota.
Ralph K. Ghormley, M.D., Rochester, Minnesota.

Sympathetic Block of the Stellate Ganglion: Its Application in Orthopaedic Conditions.
Guy A. Caldwell, M.D., New Orleans, Louisiana.
T. F. Broderick, M.D.
R. M. Rose, M.D.

The Operative Treatment of Scoliosis—A Corrective Appliance Supersedes the Bent Cast.
Walter P. Blount, M.D., Milwaukee, Wisconsin.
Albert C. Schmidt, M.D., Milwaukee, Wisconsin.

Segmentations During Contraction of Mammalian Skeletal Muscle.
J. E. Markee, M.D., Durham, North Carolina.
H. Lowenbach, M.D., Durham, North Carolina.

Use of the Three-Flanged Nail in Knee Fusion.
David M. Bosworth, M.D., New York, N. Y.

TUESDAY, JANUARY 22

Morning Session

Indications and Results from Mold Arthroplasty and Other Plastic Operations on the Hip.
Paul H. Harmon, M.D., Milton, West Virginia.

Arthrodesis of the Hip, Brittain Type.
Joseph A. Freiberg, M.D., Cincinnati, Ohio.

Treatment of Congenital Dislocation of the Hip.
Edward L. Compere, M.D., Chicago, Illinois.

Mobilization of the Metacarpophalangeal Joints—Arthroplasty and Capsulotomy.
Captain Samuel B. Fowler, M.C., A.U.S.

Psychological Problems Observed in Military Orthopaedic Surgery.
Major J. Vernon Luck, M.C., A.U.S.

Factors Influencing Bone Repair in Open Reductions of Fractures.
Jean Verbrugge, M.D., Antwerp, Belgium.

Afternoon Session

Treatment of Compound Comminuted Fractures of the Elbow Joint by Resection of Fragments.
Commander J. T. Nicholson, M.C., U.S.N.R.

Restoration of Bone Strength with Reinforcement Bone Grafts.
Lieutenant Colonel George K. Carpenter, M.C., A.U.S.
Major Robert T. Rosenfeld, M.C., A.U.S.
Major Karl F. Mech, M.C., A.U.S.

Reconstruction of Defects of Tibia and Femur with Apposing Massive Grafts from the Affected Bone. A Preliminary Report.
Major John J. Flanagan, M.C., A.U.S.
Captain Henry S. Burem, M.C., A.U.S.

Skin Grafting in the Treatment of Osteomyelitis.
Lieutenant Colonel Robert P. Kelly, M.C., A.U.S.

Overseas Treatment of Compound Fractures of the Long Bones.
George O. Eaton, M.D., Baltimore, Maryland.

WEDNESDAY, JANUARY 23

Morning Session

Neurectomy to Produce Atrophy of Amputation Stump.
Alfred O. Adams, M.D., Spokane, Washington.

Conservation of Short Amputation Stumps by Utilization of Tendon Section.
Lieutenant Colonel Harry C. Blair, M.C., A.U.S.
Major Harry D. Morris, M.C., A.U.S.

The Technique of the Syme Amputation.
Major R. H. Alldredge, M.C., A.U.S.
Lieutenant Colonel T. C. Thompson, M.C., A.U.S.

Amputation of Upper Extremity.
Captain H. H. Kessler, M.C., U.S.N.

Amputations of the Lower Extremity.
Commander D. D. Toffelmier, M.C., U.S.N.R.

Afternoon Session

Disability Evaluation of the Hand.
Major Donald B. Slocum, M.C., A.U.S.
Captain Donald R. Pratt, M.C., A.U.S.

Cellophane in Reconstructive Orthopaedic Surgery.
Duncan C. McKeever, M.D., Houston, Texas.
Operative Creation of New Gliding Channels for Tendons and Muscle Bellies.
Major J. E. Milgram, M.C., A.U.S.
The Repair of Knee Ligaments by Cutis Graft Transplants.
Randolph L. Anderson, M.D., Charleston, West Virginia.
Semi-Delayed Bone Graft for Subcapital Fractures of the Hip.
Arch F. O'Donoghue, M.D., Sioux City, Iowa.

THE BRITISH ORTHOPAEDIC ASSOCIATION

The Annual Meeting of the British Orthopaedic Association was held at the Royal College of Surgeons of England on October 26 and 27, 1945.

Mr. St. J. D. Buxton, in his presidential address, reviewed methods of preventing accidents, and stressed the importance of teaching first aid. Fatal industrial accidents have decreased in number, but there has been a steady increase in all reported accidents in recent years, particularly in injuries of the feet and hands. The financial cost and loss of production resulting from industrial accidents in England have been estimated as seventy million pounds a year. Propaganda is needed for the further education of the workman in safety-consciousness. Members of the Association were urged to aid in preventive work by inquiring as to the exact causation of accidents, and to effect closer cooperation with those concerned with industrial medicine. The surgeon's aim is to return the injured man to his work in a fit condition as soon as possible, and to reduce disability to a minimum. During treatment, the patient must be kept fit mentally as well as physically. A nationwide accident service is required, especially for industrial and road accidents.

Professor T. P. McMurray gave an interesting account of the historical background of Hugh Owen Thomas, and described the classical splint which Thomas and his disciples called the "bed knee splint". The efficiency of this appliance, which Thomas evolved in his own workshop, was emphasized. Almost all of the improvements and alterations since made in this splint had been tried out by Thomas and discarded. The details of construction, measurement, and application of the splint were described. The simplicity of the original design meant that there was little to get out of order.

Congenital Dislocation of the Hip

Professor J. Leveuf, of Paris, described his investigations, based upon arthrography and operative findings, which showed that there was a complete difference between congenital subluxation and congenital dislocation of the hip. He disagreed with the generally accepted view that subluxation is a preliminary stage, leading to dislocation. In arthrograms of dislocation, the limbus produced by the upper portion of the cotyloid ligament or cartilage was visualized as a downward projection, causing the usual hour-glass contraction; in subluxation this shadow was never found, for the limbus was pushed upward and was compressed against the ilium. In dislocation the head of the femur was small and the ligamentum teres persisted; in subluxation the femoral head was large and the ligamentum teres was absent. There was no other interposition of soft tissue in subluxation. Anteversion of the femoral neck was an early finding in subluxation; it was a late or secondary deformation in dislocation. In discussing treatment of this condition, Professor Leveuf stressed the need of getting a hip in which the femoral head conformed to the acetabulum. Closed reduction was only suitable under the age of two years; after this age he favored operation. In those cases requiring reconstructive work to restore the bony conformation, he favored a transtrochanteric intra-articular approach, in which osteotomy of the femoral neck was carried out, if necessary, and the acetabulum was deepened by turning down its roof and inserting a graft above it.

Mr. J. S. Batchelor reviewed the problem from the point of view that congenital dislocation of the hip was an external rotation-adduction deformity with three stages of severity. Treatment consisted in correction of soft-tissue contracture by gradual abduction, followed by manipulative reduction and reversal of the deformity with encouragement of normal development by function. For this purpose he used knee plasters joined together by a crossbar; the hips were held in abduction and internal rotation, but were otherwise free to move in flexion and extension. For cases showing redislocation, anteversion, and valgus of the femoral neck, osteotomy to reduce these deformities was carried out after the femoral head had been replaced in the acetabulum.

Mr. H. A. T. Fairbank remarked that Professor Leveuf appeared to do open operations more often than was thought necessary in England, yet his results were excellent. Hitherto Mr. Fairbank had thought that the problems of anteversion and valgus had been overstressed; evidently he was wrong. Anterior transposition or anterior dislocation, he thought should be left alone, since patients with this condition walk very well.

Professor Harry Platt, speaking from more than thirty years' experience with nearly 500 cases,

strongly supported Professor Leveuf's view that subluxation and dislocation were two distinct morphological entities. He also believed that the femoral heads were naturally placed posteriorly in many cases and anteriorly in others. He denied that the former could be forced into the latter position, and he also believed that the position of marked internal rotation was dangerous for fixation.

Mr. G. R. Girdlestone expressed anxiety over the risks of avascular changes in the femoral head after extensive intra-articular operations.

Sir Reginald Watson-Jones, supporting Professor Platt's views, thought that there were many morphological types. He distinguished three main types from the point of view of treatment. The first group included those hips which were reduced in full abduction, and after a year remained reduced. In the second group, after a year of abduction, the hip tended to subluxate soon after the patient was allowed to kick about in bed. In the third group, despite full abduction, the heads were never fully replaced in the acetabula. The second and third groups required operative treatment, and patients in the third group should be recognized early and operated upon promptly. He believed that there was less risk of osteo-arthritis in cases with incongruity of capital and acetabular form than there was in those with avascular changes in the femoral head. For this reason he felt that a long period of observation was needed before Professor Leveuf's results could be judged.

Mr. B. L. McFarland regarded anterior transposition as meaning the riding of the femoral head under the rectus tendon and Y-shaped ligament; it was not a complete anterior dislocation. The more he had seen of acetabuloplasty, the less satisfied was he with the results. Remolding of the hip joint was dependent upon the proper direction of the thrust of the femoral head into the acetabulum; therefore he advised maintenance of abduction during the early walking stages of treatment.

Miss Maud Forrester-Brown urged the importance of the functional care of muscular activity.

Professor Leveuf, in reply, said that true dislocation was more difficult to reduce by non-operative methods; the ease of "reduction" in subluxation was deceptive and the results by this method were likely to be disappointing. If the hip was left in a state of subluxation, osteo-arthritis would be certain to occur. He stressed the value of the arthrogram, not only for diagnosis, but also as the most satisfactory test for reduction. He was convinced of the value of his complete operation. In 202 cases in which he had done open operations, he had had only one case of necrosis of the femoral head. The secret was that there was no interference with the blood supply which entered the femoral head from the soft tissues below the femoral neck.

Mr. Batchelor remarked that his method of holding the hip joints, while allowing movement, ensured the maintenance of extension as well as of flexion. He had had no trouble with stiffness, resulting from the internally rotated position. The happiness and comfort of the patients was noteworthy. If stiffness occurred, it was due to mismanagement.

Orthopaedics in Medical Education and in Regional Hospital Services

Starting with the definition of Robert Jones that orthopaedics is "the treatment by manipulation, operation, re-education, and rehabilitation, of the injuries and diseases of the locomotor system", Professor Harry Platt of Manchester reviewed the evolution of specialism in surgery, or differentiation, as a changing pattern. There are two fundamental requirements: each surgical specialty must continue to advance the general craftsmanship of surgery, and—of even greater significance—it must contribute to general ideas. Richness of technological advances does not compensate for poverty of ideas or of vision. The recruitment of men and women, trained in scientific and historical methods and with high standards of scholarship, is needed for the preservation of vitality in the differentiated fields. Professor Platt regarded abdominal surgery as the "romantic" movement in surgery, with its growth during the twentieth century; orthopaedics, embracing a large part of the general surgery practised by the nineteenth-century surgeon, he regarded as being rooted in the classical period. The automatic right of the abdominal surgeon to assume leadership in the affairs of surgery can no longer be admitted. A plea was made for more satisfactory integration of undergraduate teaching in orthopaedics,—not to instill the details of complicated techniques, but to introduce and to explain to the student the clinical phenomena of the disorders of locomotion, the biological and social background of crippling disease, and the ancient therapeutic methods of rest, fixation, and purposive movement. Orthopaedic teaching must permeate the undergraduate course. In postgraduate education three types of instruction were considered: the training of the orthopaedic surgeon of the future; postgraduate instruction of the short intensive type; and training for higher degrees or diplomas in orthopaedics, the desirability of which was doubted.

In the Regional Hospital Service of the future, the orthopaedic services were envisaged as of two types. In an area with a population of 150,000, one orthopaedic-accident surgeon would be associated with two general surgeons in the key hospital, his time being devoted predominantly to the problems of trauma. Such an area unit would not supply enough examples of the rarer orthopaedic problems to enable the peripheral orthopaedic surgeon to become expert in their handling. Certain types of work, such as the long-term care of the crippled child and of surgical tuberculosis, were already, in effect, regionalized by State action. Some of the more specialized orthopaedic problems must be directed either

to university centers or to county orthopaedic hospitals. The link between central and peripheral orthopaedic departments must be preserved through the association of the staffs of one with the other.

Epidemic of Poliomyelitis

Professor H. J. Seddon of Oxford, in describing an epidemic of poliomyelitis in Mauritius, found that the evidence strongly suggested the transmission of the disease through personal contact. He described the conditions of this colony, with its mixed population, and its difficult social and economic state. Later he outlined a scheme for the advancement of orthopaedics in the Colonies, where great opportunities exist for young orthopaedic surgeons. The appointment of such men would be part of a scheme that related them to orthopaedic establishments at home, through which, after three years or so, their future security would be assured.

Splint Construction

Mr. Norman Capener of Exeter demonstrated two splints, which he thought embodied a new principle in splint construction. They were based upon existing types used for the substitution, or support, of deficient muscle activity, as in the familiar toe-raising spring for paralytic equinus. Such appliances usually had springs attached to a rigid framework, whereas the present appliances were themselves constructed into "lively" springs. The appliance for drop-foot, in which the upright element (either single or double) was suitably tempered and coiled at the level of the ankle joint, had the advantage of permitting some lateral mobility in the foot. The second splint, used in ulnar intrinsic paralysis, was based upon an original design, produced by Mr. A. M. Hendry and his co-workers at Derwen, Oswestry, and possessed great advantages of "liveliness" over previous ulnar splints, which rigidly maintained flexion of the knuckle joints.

Arthrography of the Knee Joint

Squadron Leader E. Somerville, Royal Air Force, demonstrated an improved technique for the diagnosis of lesions of the knee joint by air arthrography. A series of 331 knees had been investigated and a very high degree of accuracy in diagnosis had been achieved. Success depended upon attention to the following details: The joint was examined under anaesthesia and filtered air was injected until it was full; the intra-articular pressure was then temporarily increased by bandaging over the suprapatellar pouch; the joint was placed in position over a curved cassette; a sinus cone was used; and radiation was directed accurately in seven tangential planes.

The Fractured Femur

Three different methods of treating simple extra-articular fractures of the femur were discussed.

Mr. R. G. Pulvertaft of Grimsby dealt with fractures of the trochanteric region, for which he preferred the Hamilton Russell method of balanced traction without splintage. The advantages of this method were efficient traction with the joints in the optimal position; complete comfort and muscular relaxation; the maintenance of muscular condition and knee-joint movement; and reduction of chest and decubitus complications, owing to the freedom of the patient to sit up and change position. Careful supervision was essential. This method had given a high proportion of favorable results.

Major John Charnley of the Royal Army Medical Corps, in discussing the treatment of fractures of the femoral shaft by fixed skeletal traction, stressed the importance of controlling lateral angulation and of maintaining immobilization of the fracture, and therefore of the knee joint, for fully eight weeks. A special apparatus, which he had devised, was used in conjunction with the Thomas splint; it was especially designed to give precision, and to be relatively foolproof after accurate adjustment by the surgeon. The essentials were traction upon a pin through the upper end of the tibia, pulling along a line posterior to the femoral axis, with the femur supported across an especially shaped, padded metal fulcrum. Lateral control was achieved by pads screwed to adjustable attachments to the lateral bars. Early movement of the knee was inadvisable and unnecessary.

Mr. G. R. Fisk adopted a completely opposite course for fractures of the femoral shaft. He established early movement by the use of skeletal traction in a flexing splint; this was made from a Thomas splint, sawed off at the knee level and joined by an articulation of the Pearson type.

Mr. V. H. Ellis, in a study of 420 recent fractures of the femoral shaft, supported the advocates of early movement of the knee. The causes of limited flexion were intra-articular adhesions, fixation of the quadriceps, scarring in the region of the fascia lata, especially in high compound fractures, and transfixion of the muscle by spicules of bone.

Actinomycosis

Mr. C. H. Cullen of Winwick reported on five cases of actinomycotic infection of gunshot wounds, in four of which the organism was of an unusual aerobic type. All of the cases were chronic and resistant to treatment. Adequate surgical measures, combined with penicillin, seemed to be of most use. It was interesting that penicillin was beneficial in cases in which concomitant organisms were insensitive to penicillin.

Pollicization of the Index Finger

Mr. E. W. Bintcliffe demonstrated two patients whom he had successfully treated, in conjunction with Major Kilikian, United States Army Medical Corps, by pollicization of the index finger after amputation of the thumb. In such cases, the web space between the index finger and the middle finger was deepened by dissection. The second metacarpal was divided, allowing the index finger to be abducted, and was attached by wire sutures either to the remains of the first metacarpal or to the trapezium. The defect created between the new thumb and the middle finger was filled by a skin graft. It was desirable to carry out abduction by traction, with a wire transfixing the index finger. The two patients shown had very good function in the "thumbs" thus produced.

Clinical Photography

Mr. P. G. Hennell stressed the importance of color reproduction in clinical photography as an aid to scientific recording and medical education. He believed that in five years black-and-white photography would largely have been superseded by color in the production of scientific records. The apparatus which he had used in clinical photography was demonstrated, as well as a wide selection of color photographs of surgical procedures.

At the meeting on October 26, the following Associate Members were elected:

A. Anderson Bonar, F.R.C.S.E., Ashington, Northumberland.
Miss R. E. M. Bowden, M.B., B.S., London, W.C.1.
Hedley W. Hall, F.R.C.S., Winchmore Hill, N. 21.
Capt. T. P. N. Jenkins, R.A.M.C., Surbiton, Surrey.
Capt. I. N. McIver, R.A.M.C., Colchester.
Lt. Col. C. M. Marsden, R.A.M.C., Millbank, London, S.W.1.
D. A. Richmond, F.R.C.S., Ulverston, Lancashire.
Squad. Ldr. D. P. Rowe, R.A.F., c/o Bank of New South Wales, London, W.1.
A. F. Rushforth, F.R.C.S., Watford, Hertfordshire.
Squad. Ldr. J. J. Williams, R.A.F., Northallerton, Yorkshire.

WAR REPRINT SERVICE OF THE JOSIAH MACY, JR. FOUNDATION

Doctor Rappleye, President of the Foundation, announces that more than 5,000,000 copies of over 400 leading medical and scientific articles have been published by the Foundation's War Reprint Service during the last three years for medical officers of the Armed Forces of the United States and, in so far as possible, Canada, England, New Zealand, Australia, the Union of Socialist Soviet Republics, and China. Doctor Rappleye said that, with the plans for demobilization of the Armed Forces, the Reprint Service will be discontinued by January first.

The Reprint Service of the Foundation has been an effort to bring new and important developments in the science and practice of medicine to medical officers who were largely cut off from the sources of medical information during the war. In the selection of these articles, the Foundation has had the active cooperation of the Committee on Pathology of the National Research Council and of the National Committee for Mental Hygiene. The articles selected for reprint and distribution were those dealing with the most recent scientific developments which had a direct bearing on medical and health problems related to military service. The distribution to the medical officers was worked out in cooperation with the Surgeons General of the Army and Navy and the Air Surgeon. Through the courtesy of the National Committee for Mental Hygiene, more than 1,000,000 reprints were delivered to medical officers of neuropsychiatric units.

In addition to the articles reproduced from journals, the Foundation has published for the Air Surgeon five original monographs, prepared by medical officers of the Army Air Forces, dealing with personality disturbances occurring in combat zones. Over 95,000 copies of these monographs were distributed by the Reprint Service as official documents of the Office of the Air Surgeon. Eight additional monographs and nine reviews of medical literature on subjects of military interest have been prepared and 70,000 copies distributed.

Since August 1944, a News Letter for the Rheumatic Fever and Streptococcus Control Program of the Army Air Forces has been published monthly for the Air Surgeon, and over 1,000 copies each month have been mailed to interested medical officers, military hospitals, and medical-school libraries.

Through the cooperation of the Interdepartmental Committee on Cultural and Scientific Cooperation of the Department of State, 60,000 reprints have been distributed to medical teachers and investigators in forty-eight foreign countries. The Office of War Information requested permission to circulate the Foundation's reprints among more than thirty foreign Outposts, and has reduplicated selected articles for distribution to medical leaders abroad.

The Foundation has expended over $225,000.00 in financing the War Reprint Service.

Surgeons announcing their return to civilian practice from service in the Armed Forces include the following:

Edgar M. Bick, M.D., 1112 Park Avenue, New York 28, N. Y.
John J. Donaldson, M.D., 121 University Place, Pittsburgh, Pennsylvania.
Claude B. Smith, M.D., 603 Atlas Building, Charleston 1, West Virginia.

ACKNOWLEDGMENTS

The Journal wishes to acknowledge receipt of the following publications, which were sent to the Editorial Department:

Anais Paulistas de Medicina e Cirurgia (São Paulo, Brasil), **50**: Nos. 1 e 2, 1945.
Analecta Medica (Mexico), **6**: Nos. 1 y 2, 1945.
Boletím do Sanatório São Lucas (São Paulo, Brasil), **7**: Nos. 1 e 2, 1945.
Boletín del Colegio Médico de la Habana (Cuba), **8**: Núms. 8, 9, 10, y 11, 1945.
Boletines de la Sociedad de Cirugía de Rosario (Argentina), **12**: Nos. 2 y 4, 1945.
Brasil Médico-Cirúrgico (Rio de Janeiro), **7**: Nos. 2 e 3, 1945.
The Bulletin of the U. S. Army Medical Department (Carlisle Barracks, Pennsylvania), **4**: Nos. 4 and 5, 1945.
Child Development Abstracts and Bibliography (Washington, D. C.), **19**: Nos. 3 and 4, 1945.
Cleveland Clinic Quarterly (Ohio), **12**: No. 4, 1945.
Department of Public Health, City and County of San Francisco (California), Venereal Disease Information, 1945: "An Experiment in the Psychiatric Treatment of Promiscuous Girls" by E. G. Lion, H. M. Jambor, H. G. Corrigan, and K. P. Bradway.
Médica (Matanzas, Cuba), **4**: Núms. 4 y 5, 1945.
The National Foundation for Infantile Paralysis (New York, N. Y.), National Foundation News, **4**: Nos. 11 and 12, 1945.
Radiography and Clinical Photography (Rochester, New York), **21**: No. 2, 1945.
Sanidad y Beneficencia Municipal (Habana, Cuba), **5**: Núm. 1, 1945.
Sociedad de Cirugía de Córdoba (Argentina), **5**: Nos. 6, 7, 8, y 9, 1944; **6**: Nos. 1, 2, 3, y 4, 1945.
United States Public Health Service (Washington, D. C.), Public Health Bulletin No. 293: "The Toxicity of Molybdenum" by L. T. Fairhall, R. C. Dunn, N. E. Sharpless, and E. A. Pritchard; Public Health Reports, **60**: Nos. 40 to 47, 49, and 50; Supplement No. 186; The Journal of Venereal Disease Information, **26**: Nos. 10 and 11, 1945.

Current Literature

THE INTERVERTEBRAL DISC. WITH SPECIAL REFERENCE TO RUPTURE OF THE ANNULUS FIBROSUS WITH HERNIATION OF THE NUCLEUS PULPOSUS. F. Keith Bradford, M.D., and R. Glenn Spurling, M.D. Ed. 2. Springfield, Illinois, Charles C. Thomas, 1945. $4.00.

Less than a dozen years ago, there was added to the list of common causes of low-back pain and sciatic pain the clinical entity of a ruptured intervertebral disc. It soon became evident that disc lesions accounted for many of these cases. So important is this problem in clinical practice that the literature on the subject has become extremely voluminous. It is difficult—perhaps impossible—for the general practitioner and surgeon to read and assess the value of the flood of articles about disc lesions. The profession therefore welcomed the first edition of Bradford and Spurling's small volume. It has saved innumerable hours of reading, and offers in one compact volume, well illustrated, practically all of the present knowledge concerning the intervertebral disc.

The second edition of this volume brings this information up to date. There is very little to criticize, and much to praise. The reviewer feels that the authors might well have laid more emphasis on the value of combined removal of the ruptured intervertebral disc and spinal fusion, as the present trend is toward stabilizing the spine by means of fusion at the time the laminectomy is done. This volume should be on the book shelf of everyone treating patients with low-back pain and sciatic pain.

ATLAS OF SURGICAL APPROACHES TO BONES AND JOINTS. Toufick Nicola, M.D., F.A.C.S. Foreword by Norman T. Kirk, The Surgeon General, United States Army. New York, The Macmillan Company, 1945. $5.00.

The principle of visual education is applied to orthopaedic surgery in an atlas which should prove of value alike to the student and to the practising surgeon. Drawings made from his own anatomical dissections have been produced by Nicola to illustrate clearly each step in the various surgical approaches to the bones and joints, beginning with the skin incision and proceeding in anatomical sequence. The illustrations are accompanied by a brief description of the course to be followed and some of the pitfalls to be avoided, but the text does not include a discussion of surgical techniques, because the author believes each surgeon will develop his own.

The clarity and conciseness of this work make it useful as a reference book, as well as a working guide.

PEDIATRIC X-RAY DIAGNOSIS. A Textbook for Students and Practitioners of Pediatrics, Surgery and Radiology. John Caffey, A.B., M.D. Chicago, The Year Book Publishers, Inc. 1945. $12.50.

During the past thirty-five years, no textbook of diagnostic roentgenology in infants and children has appeared in the English language. The need has been acute, as it is often all too obvious that the training of the average roentgenologist in roentgenographic diagnosis in children has been insufficient, and his interpretations are, therefore, faulty. Many pediatricians and surgeons have attempted roentgenographic diagnosis with an insufficiently broad background, and for them a book, written by a roentgenologist, can present a considerable accumulation of useful knowledge in this field.

All phases of disease in early life are dealt with, and, from the vast experience of the Babies' Hospital in New York, Caffey is able to present much that is new and not readily available. This material proves interesting, and the illustrations and drawings are excellent. One regrets that certain aspects of disease appear incomplete or superficial, and that some conditions are not even mentioned, but probably the subject had become too large for complete treatment in a single volume.

The book is divided into six sections: the head and neck, the thorax, the abdomen and gastro-intestinal tract, the pelvis and genito-urinary tract, the extremities, and the vertebral column. Each section is headed by an excellent discussion of the normal and developmental anatomy. Many of the normal variants and nearly all diseases peculiar to early life are lucidly described and beautifully illustrated. The bibliography is adequate, although incomplete. The chapters on the spine and extremities are particularly good and should be of considerable interest to orthopaedic surgeons.

To all who have occasion to examine the roentgenograms of infants and children, the book should be of inestimable value, not only because there is no other text available in English, but because Caffey presents a book replete with useful information in a style that makes the reading of his text extraordinarily profitable and a real pleasure.

AMPUTATION PROSTHESIS. ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS, WITH PRINCIPLES OF ALIGNMENT AND FITTING DESIGNED FOR THE SURGEON AND LIMB MANUFACTURER. Atha Thomas, M.D., F.A.C.S., and Chester C. Haddan. Philadelphia, J. B. Lippincott Company, 1945. $8.00.

This book is a practical guide in the problems of extremity prosthesis. The selection of the site of amputation and the accredited technique of the present day in the creation of the stump, its aftercare

and conditioning, are correlated with the proper fitting and alignment of the prosthesis. The materials, mechanisms, sockets, and suspension apparatus are clearly and authoritatively presented from the practical standpoint.

The chapter on alignment and fitting is especially well done, and fills a long-felt need. It should be of great benefit to all concerned. Indeed, the entire book is well done. The upper-extremity prosthesis is fully discussed, and the shortcomings are presented in a straightforward and stimulating manner. The chapter on prostheses for children adequately covers a neglected field and adds to the merit and value of the book.

This 289-page volume is the result of the collaboration of two authorities on the subject, one a well-known orthopaedic surgeon, the other an experienced limbmaker. Both are thoroughgoing students of their respective fields. The book is a valuable addition to the orthopaedic library.

GENERAL AND PLASTIC SURGERY, WITH EMPHASIS ON WAR INJURIES. J. Eastman Sheehan, M.D. New York and London, Paul B. Hoeber, Inc. (Medical Book Department of Harper Brothers), 1945. $6.75.

This book was written by a well-known plastic surgeon, who has published several treatises on plastic surgery and has seen a good deal of war surgery in Spain and Britain. He has endeavored to show the application of the principles of plastic surgery to general surgery, but most of the book is devoted to general surgery with particular reference to battle injuries. Sheehan has borrowed many of his facts and many illustrations from Bailey, who has published a great deal on traumatic surgery. The author gives credit to many plastic surgeons, both at home and abroad, for helpful suggestions in preparing the book, which is written with the hope that lessons learned from the War may be applied to peacetime surgery.

The first chapter deals with general considerations, including the types of missiles found in various types of fighting, the types of wounds made by such missiles, the need for prompt treatment, methods used to combat shock and pain, and the indications and techniques for plasma transfusions.

Subsequent chapters take up wound excisions, gas gangrene, control of infections, blast injuries at sea and on land, and the treatment of burns. The chapter on wounds and burns of the hand and foot is excellent, and deals with the anatomical as well as the surgical aspects. Wounds of the various regions are considered in order, and the basic plastic procedures are described. The illustrations are excellent.

This is an unusual book and of great value.

THE OSSEOUS SYSTEM. A Handbook of Roentgen Diagnosis. Vincent W. Archer, M.D. Chicago, The Year Book Publishers, Inc., 1945. $5.50.

Archer has prepared a concise handbook on the roentgenographic diagnosis of the osseous system, which he dedicates to the occasional roentgenologist. It contains an excellent choice of reproduced roentgenograms, representative of bone abnormalities, varying from congenital anomalies and fractures to bone tumors and metabolic disorders. The contents are so arranged as to afford quick reference.

Two points are stressed throughout: First, commonplace errors in the interpretation of shadows are demonstrated so that these pitfalls can be avoided; and, second, the differential diagnoses are given consideration so that alternate possibilities will not be overlooked. This handbook will give assurance to the interpretations of the occasional roentgenologist, and at the same time clearly indicate the zone in which more expert opinion is necessary. It is better suited to a place beside the viewing box in the office or hospital than in the index files of a large library.

THE EXTREMITIES. Daniel P. Quiring, Ph.D., Beatrice A. Boyle, Erna L. Boroush, M.A., and Bernardine Lufkin, A.B. Philadelphia, Lea & Febiger, 1945. $2.75.

Although entitled "The Extremities", this small book is devoted entirely to a delineation of the muscles of the upper and lower extremities,—their origins, insertions, actions, blood supply, and nerve supply.

At first glance the drawings seem "flat", but careful examination shows that they have accomplished their purpose in showing clearly and accurately the individual muscles depicted.

A page is devoted to each muscle. The diagrammatic sketch of the muscle is shown, followed by concise statements as to origin, insertion, and function of the muscle, as well as the nerve and artery which supply it. Included also are references to Gray's Anatomy and to Cunningham's Text-Book of Anatomy.

Since all the drawings are based on original dissections, the little book represents a tremendous amount of work. It will be a valuable handbook for medical students and physiotherapists, as well as a reference book for physicians.

PHYSICAL CHEMISTRY OF CELLS AND TISSUES. Rudolf Höber (with the collaboration of David I. Hitchcock, J. B. Bateman, David R. Goddard, and Wallace O. Fenn). Philadelphia and Toronto, The Blakiston Company, 1945. $9.00.

The subject matter of this book is physiology as a branch of physiochemical science, dealing with life as a physical, although exceedingly complex, system that may be subjected to scientific analysis, as any natural object.

The book is divided into sections, beginning with the fundamentals of classical physical chemistry and cell physiology. The permeability of the cell membrane to organic non-electrolytes and to electrolytes, to weak bases and weak acids, and to dyestuffs, is considered. The present status of our knowledge of the plasma membrane is discussed and reviewed. The influence of some extracellular factors on cellular activity is considered. An attempt is made to present the general pattern of cellular respiration. Physical chemistry furnishes the theoretical basis for understanding the apparent complexity of cell respiration, and for supplying tools to probe within the living cell and to separate and study the individual enzymes. One section is devoted to the study of contractile tissues. The last, and a very important section, deals with intestinal absorption, urine formation, elaboration of digestive juices, and the permeability of the body surface of animals and plants.

This book does not claim to offer universal information in the field of the physical chemistry of cells and tissues, but it is of great value as a guide to the biologist, the chemist, the physicist, the physiologist, and the physician by bringing together, in concrete form, the fundamental laws of science upon which human physiology is built. With its diagrams, formulae, and fundamental laws, it will meet a real need as a reference book.

FRACTURES AND ORTHOPAEDIC SURGERY FOR NURSES AND MASSEUSES. Arthur Naylor, Ch.M., M.B., M.Sc., F.R.C.S.(Eng.), F.R.C.S.(Edin.). Foreword by Ernest Finch, M.D., M.S.(Lond.), F.R.C.S.(Eng.). Baltimore, The Williams and Wilkins Company, 1945. $5.00.

This book, as stated in the preface, was written for the purpose of showing the nurse how the principles of general surgery are applied in orthopaedic surgery; it is apparently designed to help nurses and masseuses understand and follow the principles of orthopaedic surgery. It is an interesting book, well written and illustrated, and contains some very clever diagrams. The descriptions are good. As its title suggests, it covers fractures and general orthopaedic subjects. No detailed surgical technique is described and there is no bibliography, although the procedures of other surgeons are occasionally mentioned in the text.

Although it is an excellent book for nurses in terms of orthopaedic surgery and fractures, it gives no nursing technique. For medical students, it would supplement the larger orthopaedic texts. It is, of course, written from a British point of view, so some of the procedures may not be quite familiar to the American reader. Most of the apparatus depicted is good, but Naylor still advocates certain forms of apparatus, such as the old Thomas hip splint and hip frame, which are no longer in general use in the United States. The principles of treatment are sound, and there is an excellent index.

ACUTE INJURIES OF THE HEAD. THEIR DIAGNOSIS, TREATMENT, COMPLICATIONS AND SEQUELS. G. F. Rowbotham, B.Sc., F.R.C.S. Foreword by Norman M. Dott, M.B., Ch.B., F.R.C.S. Ed. 2. Baltimore, The Williams and Wilkins Company, 1945. $8.50.

The appearance of a second, enlarged edition of Rowbotham's book, the only modern British treatise on head injuries, was to be expected in view of the special circumstances which prescribed its original content.

The first edition of 277 pages appeared in 1942. It was prepared to meet a critical need, arising out of the exigencies of the British national emergency. Global war had placed the responsibility of managing acute head injuries in the hands of many who were without special training in neurosurgery. There was no authoritative British treatise to which they could turn for guidance until Rowbotham's monograph appeared. It was, quite understandably, concerned with war injuries to the exclusion of certain peacetime problems. Revision with enlargement of scope was necessary, if the book was to become a standard work on its subject, as predicted by British reviewers.

The author's qualifications for an undertaking of this nature are ample. He is the senior pupil of Professor Jefferson, the dean of British neurosurgeons, who has long been preoccupied with the problems arising out of head injuries. The author has so ordered his affairs that his own clinical experience in this field is now considerable. He is, in addition, a student and investigator of his subject, with a faculty for clear exposition.

The second edition of this book, replete with superb original illustrations, attempts to compress within 414 pages an account of the mechanisms, pathology, diagnosis, treatment (operative and non-operative), sequelae, and rehabilitation of practically every known type of head injury.

Although the book is an admirable piece of work, it would have profited by the author's calling

more freely upon the experience of others in places where his own experience appears to be slight. Thus, in the discussion of the subdural hematomata of infancy, no mention is made of the diagnostic and therapeutic usefulness of subdural taps. Equally important omissions occur in the presentation of carotid-cavernous sinus fistulae. At these and a few other points, deficiencies are not covered by appropriate references.

Parts of the book suffer from an avoidable lack of perspective. Thus in a twenty-four-page account of epilepsy, medical treatment is afforded a single paragraph, in which the clinical toxicology of the anticonvulsive agents and measures for the control of status receive no mention. Similarly, the subject of chemotherapy and of antibiotic therapy is alloted but two pages, wherein space is found for historical data on penicillin but not for the clinically important matters of intrathecal administration and the choice of agents for direct application to cerebral tissue.

Because of the author's attempt to cover so much ground in so few pages, the book cannot be recommended in its entirety to any one audience. The rather large sections devoted to operative technique will be helpful to neurosurgical house officers, but lost on practitioners, and incomplete for specialists. On the other hand, the chapters dealing with mechanisms, pathology, and rehabilitation recommend themselves highly to student, house officer, practitioner, and specialist. The book certainly belongs in the libraries of medical schools and hospitals.

PHYSICAL TREATMENT BY MOVEMENT, MANIPULATION AND MASSAGE. James B. Mennell, M.A., M.D., B.C.(Cantab.). Ed. 5. Philadelphia, The Blakiston Company, 1945. $7.00.

This book maintains a unique position among texts on physical therapy as a very personal book. The signal skill and understanding of the author, acquired from years of experience in treating patients with physical methods, are divulged in detail. Unlike many American textbooks, which consist largely of a compilation of the literature on the subject, in this book one finds but brief reference to the writings of others. Nowhere else, in fact, can one find the information contained in this volume. The technique of massage, manipulation, and exercise is described in explicit detail, often with considerable repetition when essentially the same methods are used for different disease conditions. The physiological effects and the rationale of treatment are based largely on *a priori* reasoning, from apparent good results. This is unavoidable to a large extent, because of lack of scientific research in the field. One feels the considerable enthusiasm of the writer in ascribing value to the methods described, but at the same time warnings of possible lack of usefulness and even contra-indications to treatment are included.

As is to be expected, the discussion largely centers on those orthopaedic conditions for which massage and exercise are outstandingly advisable. Heat, electricity, and other physical agents are only briefly mentioned.

More detail of technique of physical methods is included than will interest the average orthopaedic surgeon or physician. On the other hand, to properly prescribe and instruct the physical therapist in the care of patients, considerable knowledge of this subject is essential. The surgeon who will take the time to read this book and to learn the possibilities of physical treatment will acquire practical information, which should lead to more intelligent use of physical therapy, and better results from it. This book is practically essential for student physical therapists in England, and is worthy of study by all.

A TEXTBOOK OF SURGERY. By American authors. Edited by Frederick Christopher, B.S., M.D., F.A.C.S. Ed. 4. Philadelphia and London, W. B. Saunders Company, 1945. $10.

The roster of contributors to this volume includes many surgeons who are recognized as authorities in special phases of surgery. An unusual number of changes in this list have been necessary since the previous edition. The constant improvement in techniques and methods means that such a book must have frequent revisions, if it is to be kept up to date. Since the previous issue, so many developments have come in this field that whole new chapters were necessary in this edition, as, for example, the chapter on chemotherapy in surgical infections.

Excellent illustrations, adapted from many sources, help in the understanding of the text.

Since 1936, when this work first appeared, it has been recognized as a valuable reference book. This fourth edition makes more secure its position as a text of unusual merit.

FRACTURES OF THE JAWS. Robert H. Ivy, M.D., D.D.S., F.A.C.S., and Lawrence Curtis, A.B., M.D., D.D.S., F.A.C.S. Ed. 3. Philadelphia, Lea and Febiger, 1945. $4.50.

The third edition of Ivy and Curtis's book contains some additional material not included in the former editions. Stout's loop method of intermaxillary wiring has been added. A description is given of Risdon's method of constructing an arch bar with wires attached to two posterior teeth. When ligated to the teeth it gives a very firm fixation, with a close approximation to the form of the dental arch.

Skeletal fixation is described, and is recommended for fractures of the mandible in order to control fragments in which teeth are absent or do not afford adequate attachment for intra-oral appliances. For maxillary fractures, Adam's method of fixation by internal wiring has been included, in addition to the conventional procedures formerly described.

Condylar fractures are given only the most cursory consideration; fracture-dislocations are not mentioned at all. Both types of fracture are relatively common, and are best diagnosed with the aid of roentgenograms taken in an anteroposterior direction. This method is used routinely in most hospitals today, but is not described in the chapter dealing with roentgenographic technique, written by Ennis.

The methods advocated by the authors may be employed without the use of highly technical dental laboratory procedures; such procedures often consume considerable time and include the taking of impressions and the fitting of wax models, which may be very uncomfortable or even painful.

FACIAL AND BODY PROSTHESIS. Carl Dame Clarke, Ph.D. St. Louis, The C. V. Mosby Company, 1945. $5.00.

This is virtually a handbook of materials and methods used in the making of prostheses. The author obviously is familiar with the historical background, and has kept himself abreast of the modern developments in this field. His approach in this volume is more from the standpoint of a technician and artist than from that of a clinician, although for the most part his statements are medically sound.

Materials and techniques are discussed in some detail, with the exception of those which have been fully described before; these he refers to in an excellent bibliography. He describes in greatest detail the use of latex; but the passages on the use of wax, plaster-of-Paris, and agar compositions are adequate. The discussion on the coloring and the application of prostheses is quite good.

The chapter on the use of resilient and elastic resins is too brief, and the small place devoted to hard prosthetic devices is hardly justified. The chapter on the repair of cranial defects by cast chip-bone grafts is probably out of place in this volume, for it applies to a very limited field, which has more to do with the grafting of living substances than with the subject of prosthetics. One case is shown where a prosthetic nose and upper lip is used; this procedure is usually unwise, for the upper lip never looks completely normal. However, as a temporary expedient before plastic surgery is finished, such a device may be justified.

In spite of these relatively minor objections, this book may be recommended highly because of the clarity with which it is written, because of the excellent discussion of materials and methods, and because of its lack of superfluous words. It certainly should be most useful to reconstructive surgeons, medical artists, and dentists.

A TEXTBOOK OF SURGERY. John Homans, M.D. Ed. 6. Springfield, Illinois, Charles C. Thomas, 1945. $8.00.

The new edition of Homans's Surgery is a textbook of even greater value than the previous edition. It reflects the lessons of the war years, when special surgical problems have confirmed the value of many procedures and shown others to be futile. The frequent recognition of conditions, previously considered rare, has emphasized the necessity of understanding these entities. The occurrence among Army personnel of certain fractures and other injuries, seldom seen in civilian life, has provided an opportunity for evaluation of the various methods of treatment.

In this edition, as in each previous revision, the aim of the author has been to discard the outworn material and to include the accepted newer methods of diagnosis and treatment. This constant effort to keep the volume up to date explains, in part, the place which the book holds as a text for the student and a reference of value to the surgeon. The carefully prepared illustrations, as well as the bibliographic index, add greatly to the usefulness of the book.

OSTEOTOMAIS EM GERAL, SUA FREQÜÊNCIA E SUA IMPORTÂNCIA EM ORTOPEDIA (Osteotomy in General, Its Frequency and Its Importance in Orthopaedics). Dagmar Aderaldo Chaves. Rio de Janeiro, A Casa do Livro Ltda., 1943.

Chaves traces the history of osteotomies since 1815, and reviews the various indications for osteotomy. He divides osteotomies into subcutaneous and fully open, and classifies the open osteotomies as linear, complex, cuneiform, and curvilinear. The techniques of special osteotomies, such as derotation, and shortening or lengthening of a limb, are discussed. The book is well illustrated with line drawings. The case histories of nine patients who had recently undergone osteotomies are reported. Although nothing new is brought forward, the book contains a wealth of information about this special surgical procedure.

PLASTER OF PARIS TECHNIQUE IN THE TREATMENT OF FRACTURES AND OTHER INJURIES. T. B. Quigley, Lieutenant Colonel, M.C. New York, The Macmillan Company, 1945. $3.50.

The author has taken a subject which ordinarily has been taught by the apprentice method, and has put the teaching into words. This book points out the fundamentals, indications, and dangers in the use of plaster for the fixation of extremities and trunk injuries. In the matter of detailed techniques, it is dogmatic to the exclusion of alternate methods. As a reference book in the technique of plaster application, it is certainly a thorough, single set of rules, which should give to the surgeon who becomes familiar with it more confidence and quicker agility in mastering the art.

THE MEDICAL ANNUAL. A YEAR BOOK OF TREATMENT AND PRACTITIONER'S INDEX. Editors: Sir Henry Tidy, K.B.E., M.A., M.D., F.R.C.P., and A. Rendle Short, M.D., B.S., B.Sc., F.R.C.S. Bristol, England, John Wright and Sons, Limited, 1945.

The Medical Annual for 1945 is the sixty-third consecutive volume to be published in England. It is a yearbook of treatment and the practitioner's index. The many and varied conditions are presented by contributors who are recognized British authorities, each in his own field. Conditions in which new advances have been made during the year are especially discussed. The subject matter is amply illustrated by forty-seven plates and many drawings.

This volume, like its predecessors, will prove of value as a quick and handy reference book for the general practitioner, not only in the British Isles, but in America as well. Here the latest information on medicine and surgery are available in concise form. Considering the severe wartime restrictions which must have been encountered, the publishers of the Medical Annual for 1945 are to be congratulated upon producing a volume equal to the standard of Annuals of previous years.

STRUCTURE AND FUNCTION OF THE HUMAN BODY. Ralph N. Baillif, Ph.D., and Donald L. Kimmel, Ph.D. Philadelphia, J. B. Lippincott Company, 1945. $3.00.

One of the authors is Assistant Professor of Anatomy at the Louisiana State University School of Medicine and the other, Associate Professor of Anatomy at Temple University School of Medicine. They have prepared this book to meet what they feel is a real need in this branch of teaching—a simple text for an introductory course in anatomy and physiology.

The Introductory Survey which they call "Unit One" surveys the fields to be considered,—Protoplasm and Cells, Physical Organization in the Animal Body, and Organ Systems of the Body. This Unit comprises nearly a third of the book, and is intended as a background for the student to help him in understanding the physical building materials and the correlation of their structure and functions, as well as the individual organ systems and the relation of each to the body as a functioning mechanism.

The other three Units take up the eight organ systems:

Unit Two: Skeletal, Muscular, and Circulatory Systems;
Unit Three: Digestive and Respiratory Systems;
Unit Four: Urogenital, Endocrine, and Nervous Systems.

A Glossary and a good Index add to the value of the book.

Undoubtedly the book is well adapted for the group for whom it was written. It is not for the advanced medical student; it is not for the physician or surgeon, but will be valuable for his secretary; it is an interesting book for the perusal of the lay person who wishes to understand better the structure and function of the human body.

A TRÍPLICE ARTRODESE NA ESTABILIZAÇÃO DO PÉ PARALÍTICO (Triple Arthrodesis in the Stabilization of the Paralytic Foot). Dagmar Aderaldo Chaves. Rio de Janeiro, A Casa do Livro Ltda., 1943.

Chaves reviews the normal and pathological anatomy of the posterior tarsal and ankle joints, the muscular control, and the usual deformities with paralyses. The various types of stabilization of the foot and ankle joint are illustrated and described. Six cases of arthrodesis, performed at the Hospital Jesus, are reviewed. No new opinions are brought forward nor new procedures described. A full review of the literature is given.

RESULTATE DER OSTEOSYNTHESIS COLLIS FEMORIS A.M. SV. JOHANSSON (Results of Osteosynthesis of the Neck of the Femur by the Method of Sven Johansson). Arne Birch-Jensen. *Acta Chirurgica Scandinavica*, **87**: 432, 1942.

Out of sixty-three cases of fracture of the neck of the femur treated by closed reduction and nailing with Sven Johansson's modification of the Smith-Petersen nail, forty-eight were still alive for an end-result study. Forty-three were personally examined by the writer. Roentgenograms are submitted of the technical failures in eight cases. A statistical analysis is offered, with comparative analyses from

the literature. There was an immediate mortality of 4.8 per cent. The complication of necrosis of the femoral head occurred in ten cases; in seven, it appeared more than twelve months after the operation. There was definite bony healing in 54 per cent., pseudarthrosis and necrosis of the femoral head in 7.9 per cent., necrosis of the femoral head in 4.8 per cent., necrosis of the femoral head and osteo-arthritis in 3.2 per cent., and osteo-arthritis in 4.8 per cent. In 25.4 per cent. of cases there was no roentgenographic examination later than twelve months after the osteosynthesis. The functional results were good in 44 per cent., fairly good in 12.7 per cent., and poor in 27 per cent. In 15.9 per cent. the period of observation was less than twelve months.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

ARTHRODESIS IN OSTEO-ARTHRITIS OF THE HIP AND SEPTIC COXITIS SEQUELAE. Anders Karlén. *Acta Chirurgica Scandinavica,* **89**: 309, 1943.

In forty-seven cases of degenerative arthrosis and twelve cases of ancient septic arthritis of the hip, the end results following arthrodesing operations were studied. Various forms of arthrodesis were used. In the cases of degenerative arthrosis, there were only thirty-six with bony union, four with fibrous ankylosis, and six with no consolidation. Of these, the three cases with simple nailing all resulted in bony union. The combined juxta-intra-articular arthrodeses gave fifteen bony ankyloses, one fibrous ankylosis, and two complete failures. The partial intra-articular and juxta-articular arthrodeses gave twelve bony ankyloses, two fibrous ankyloses, and one complete failure. The intra-articular arthrodeses resulted in five bony ankyloses, one fibrous ankylosis, one failure, and one postoperative death. The juxta-articular arthrodeses in three cases gave one bony ankylosis and two failures.

Functionally the results were good in forty-five of the forty-six living patients. In one, a second operation prevented return to work. In two cases, the results were considered functionally good, although the patient failed to return to work for other than physical reasons.

In the twelve cases of ancient septic arthritis, bony fusion was obtained in ten patients. In one, there was failure of consolidation. There was one death. The eleven living patients all resumed their work.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

FRACTURES OF THE HEAD AND NECK OF THE RADIUS. Erik Feltström. *Acta Chirurgica Scandinavica,* **92**: 349, 1945.

An end-result study in ninety-nine cases of fracture of the radial head and neck includes eighty-nine treated conservatively and ten upon which an operation was performed. The results were good, except in five of the cases treated conservatively. One was a nine-year-old boy with an unreduced displacement of the radial head and limitation of elbow motion. The other four cases were in adults who should have had operative treatment.

On the basis of the end-result study, the writer suggests the following treatment:

1. Non-dislocated fractures should be treated conservatively.
2. Large, dislocated fragments should be excised.
3. In comminuted fractures, the head should be resected.
4. Dislocated fractures of the neck should be reduced, if necessary by open operation. If this fails, in adults resection should be performed.
5. In children, displaced fractures of the neck of the radius should be reduced by closed or by open methods. Unreduced displacement of the head causes considerable limitation of function. Resection should never be performed because of the resulting growth disturbance.
6. Immobilization should be for as short a period as possible. Active motion should be started within from two to four weeks. Massage is not indicated. The application of heat is of benefit.

—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

DEEPLY SITUATED MULTIPLE GLOMUS TUMORS. Ragnar Frykholm. *Acta Chirurgica Scandinavica,* **92**: 368, 1945.

A case is reported in which a glomus tumor, the size of a hazel nut, was removed from the fascial space between the interosseous membrane and the muscles of the calf, 10 centimeters proximal to the ankle joint. This was a case in which Bergstrand had previously reported the presence of multiple glomus tumors. According to the writer, there were only three previous reports in the literature of deep-seated glomus tumors, the remainder being superficial. He cites nine references to reports of superficial, multiple glomus tumors.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

ABNORMALITY OF THE CALCANEUS AS A CAUSE OF PAINFUL HEEL. ITS DIAGNOSIS AND OPERATIVE TREATMENT. A Fowler and J. F. Philip. *The British Journal of Surgery,* **32**: 494–498, 1945.

The writers have noted that in a certain group of patients with painful heel, a definite bursa external to the tendo achillis can be excised with complete relief. In another group with the same symptoms

no definite bursa could be found, but the skin and subcutaneous tissues showed chronic inflammation. These patients were not benefited by operation. However, roentgenographic studies showed that these patients had an abnormality in the bone consisting of a smooth, regular, prow-like projection immediately beneath the tendon at the point of disability.

This finding led to an investigation into the variations of the os calcis. Interesting illustrations of these variations are shown.

An operation has been devised to remove this excess bone. A curved incision is employed and a flap dissected downward. The tendon is cut through by an inverted "Y" incision and the projecting bone is smoothed off. The tendo achillis is sutured and the wound is closed. The foot is put up in plaster in plantar flexion for three weeks. Disability ends in six weeks. The operative results are said to be good.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

DELAYED PARAPLEGIA FOLLOWING FRACTURES OF THE VERTEBRAE. Lambert Rogers. *The British Journal of Surgery*, **32**: 514–517, 1945.

Paraplegia complicating a vertebral fracture is usually produced at once by the nipping of the cord between two vertebrae. Rarely, the onset of paraplegia is delayed, so that there is an interval between the time of injury and its appearance. During this interval conduction in the cord is unimpaired, its functions are normally discharged, and it would appear to have escaped damage. Symptoms of a spinal-cord lesion then appear; the numbness and paralysis may be either transient or lasting.

The article includes detailed reports of four illustrative cases. In all four paraplegia occurred after an interval in which there were no cord symptoms. In two cases the paraplegia lasted only a few days. In the others it was persistent, and operation was required to relieve it.

The paraplegia was due to bony compression of the cord, which probably was the result of movement of the bony fragments subsequent to the initial fracture.

INTERNAL DERANGEMENTS OF THE KNEE IN MILITARY PRACTICE. Hewson I. J. Kellam. *The Canadian Medical Association Journal*, **53**: 143–147, 1945.

The author served with the Canadian Orthopaedic Unit in Great Britain. Of a very large number of soldiers with symptoms referable to the knee, 400 cases are reviewed, in which meniscectomy was performed by various surgeons of the Unit. He makes the following observations:

Lesions of the medial meniscus are more frequent than those of the lateral meniscus.

Tears in the peripheral part of the cartilage heal more readily than those in the inner two thirds or free border, because of the vascularity of the peripheral part.

Recurrent attacks of internal derangement may occur after trivial injuries; many of them were received during skiing, football, or other athletic activities.

Careful differential diagnosis is essential to rule out, as the cause of the disability, such conditions as arthritis, tabes dorsalis, Pellegrini-Stieda disease, fracture of the anterior spine of the tibia, and injuries to the cruciate ligaments.

After a diagnosis of torn meniscus with recurrent replacement has been established, meniscectomy should not be too long delayed. The best time to operate is from twenty-five to twenty-six weeks after the first injury.

The author prefers a small anteromedial incision of either the Jones or Fisher type. When necessary, a second incision to remove the back of the cartilage is made over the posterior horn. In most cases the whole of the cartilage should be removed; when the tear is large and of the bucket-handle type, only the torn portion should be removed.

Quadriceps-setting exercises are started before operation and are resumed forty-eight hours after operation. In 250 cases the knee was immobilized in extension for three weeks; in 150, no splint was used and movement within the compression bandage was allowed. There seemed to be no difference in the results from the two methods.

Of the group of 400, 73 per cent. of those rated as A-1 upon admission to the hospital were still in this category six months to one year after discharge from the hospital.

THE USE OF PLASTICS IN PLASTER CASTS. Arthur M. Vineberg, F. G. Rice, and E. C. Brown. *The Canadian Medical Association Journal*, **53**: 170–171, 1945.

The authors have done considerable research on materials which would be suitable for casts, and yet not have the disadvantages of plaster-of-Paris. As a result of their experiments, they recommend a mixture of water-soluble plastics and plaster-of-Paris. Casts made from this mixture have been found to be 50 per cent. stronger and 10 per cent. lighter than those made from ordinary plaster. The results of the use of plastics in plaster casts are promising.

LIPOCONDRODISHOFIA (Lipochondrodystrophy). L. Expósito y A. de Feréa. *Cirugía Ortopédica y Traumatología*, **12**: 51, 1945.

The case histories of two patients suffering from lipochondrodystrophy are presented. A brother of ten and a sister of eight were brought to the Children's Clinic of the Mercedes Hospital, Havana, because of abnormality in walking. Both children showed deformities of the hands with fixed flexion of the fingers, a mild kyphos, genu varum, corneal opacity, and slight enlargement of the cranium. Laboratory studies revealed nothing significant. Roentgenograms showed osseous deformity, a flattening of the anterior part of the vertebral bodies, and flattening of the articular surfaces. No other members of the family showed evidence of the disease. The outcome in these two patients is not given.

The disease is rare, familial, and probably congenital. Lipoid substances are usually found in various tissues, particularly in the cerebrum. Theories of etiology are reviewed, and the pertinent literature is cited. Seven autopsies are recorded in the literature. The findings are somewhat similar to those of Niemann-Pick disease. Foam cells are often lacking and lipids may be deposited in granular form. The epiphyses show a small amount and an irregular arrangement of proliferating cartilage. Shortness of stature is the rule.—*John G. Kuhns, M.D., Boston, Massachusetts.*

SPINAL CARIES SIMULATING PSEUDOHYPERTROPHIC MUSCULAR DYSTROPHY. P. N. Laha. *Journal of the Indian Medical Association*, **14**: 227–228, 1945.

Laha reports an unusual case of spinal caries of the eleventh and twelfth thoracic vertebrae, which so closely simulated pseudohypertrophic muscular dystrophy that at first the latter diagnosis was made. The simulation was evidently due to compression paraplegia, in which the muscular weakness was such as to mimic muscular dystrophy. The correct diagnosis was established by roentgenogram. The author does not state whether there was any localized tenderness or rigidity in the region of the lower thoracic spine.—*Robert M. Green, M.D., Boston, Massachusetts.*

NEUROSURGICAL ASPECTS OF LUMBAR AND SCIATIC PAIN. Edgar F. Fincher. *Journal of Medical Association of Georgia*, **34**: 149–154, 1945.

Fincher deals chiefly with cartilage damage, spinal cord tumors, and neuroses. A careful chronological history is of first importance. All cartilage ruptures are due to trauma, even if the frank displacement was precipitated by violent sneezing. One may get a history of trauma in tumors of the spinal cord, but this is merely coincidental. The patients with compensation neuroses all give a history of trauma.

The character of the back pain in patients with cartilage damage is important. The pain is exaggerated on motion and intensified by coughing or sneezing, and is alleviated by complete rest. In intradural tumors the onset of pain is insidious and slow in development; it is primarily radiating, and back pain may be absent. The pain is consistently exaggerated by rest. Patients get out of bed and walk for relief. In the psychological cases the patient strives to impress the doctor with the intensity of his suffering. The back pain is diffuse in location; the extremity pain is likely to involve the entire limb, and does not follow a nerve distribution. It is always exaggerated by work and not helped by rest.

Pain due to other causes is discussed. Important signs in cartilage cases are a flattening of the lumbar curve, and a sciatic list away from the painful extremity. There is muscle splinting on the painful side. The pelvis may tilt, and patients often limp. Calf atrophy can often be determined by measuring. In cord tumors, nothing is noted on inspection in most cases. In compensation cases bizarre positions may be assumed.

The differential diagnosis is discussed. Roentgenograms are necessary; stereoscopic anteroposterior films and lateral films are made. In disc cases the films show (1) straightening of the lumbar curve, (2) narrowing of the intervertebral space, and (3) "sciatic list". Opaque injections to visualize the spinal canal are not necessary in cartilage cases, but are of value in tumor cases. They are severely condemned in psychological cases, and surgery is to be avoided in these cases.

There is much good common sense in this article, and many practical points in differential diagnosis.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

SCIATIC PAIN: ITS RELATION TO PAIN IN THE BACK AND SPINAL DEFORMITY. E. N. Wardle. *The Medical Press and Circular*, **1**: 197–201, 1945.

The author states that, of 120 consecutive cases in which the patient complained of pain in the leg, eighty-one were found to have neuralgia only, and thirty-nine, a true neuritis. Many patients with true sciatic neuralgia will admit having had attacks of intermittent back pain. Examination reveals rigidity of the lumbar spine, and painful limitation of movement in all directions. Twenty-nine cases of this type of osteo-arthritis were treated by simple immobilization of the spine in a plaster jacket for approximately four weeks. There was one failure.

Eighty cases of sciatic scoliosis, which was characterized by severe pain, list of the whole body to one side, strong spasm of one erector spina, and wasting of the whole quadriceps muscle, were treated by the application of a head-suspension plaster jacket. There were eleven failures. In some cases, laminectomy and removal of a herniated disc were indicated, and six operations were done. Four patients returned to work, one had good recovery after removal of a meningioma, and one died.

Treatment of thirty-seven cases of sciatic pain associated with congenital lumbar abnormalities was successful in twenty cases, unsuccessful in seventeen. Fifteen cases of injury to the erector spinae and lumbar aponeurosis were helped by injection of two or three cubic centimeters of a 1 per cent. novocaine solution into the painful area, and by manipulation.

YAWS. C. F. Chenoy. *The Medical Press and Circular*, **1**: 60–62, 1945.

The author has made extensive studies of yaws among jungle tribes in India. It occurs in infants, babies, children, and in young and old men and women. The cause of infection has been proved to be direct contact with primary or secondary ulcers by the broken skin. Laboratory findings among all insect vectors examined by the author were negative. He demonstrated the *Spirochaeta pertenue* in almost 100 per cent. of intact yaws lesions, in 40 per cent. of ulcerated lesions, but rarely in old lesions. Kahn's test was positive in all cases.

Three stages of the disease are described. In the primary stage, a single raised granular sore appears, after an incubation period of from two to three weeks. This lesion may heal before the onset of the secondary stage, or it may persist, or it may break down to form a persisting ulcer with granulating base and raised edges. In the secondary stage, the typical lesion is a desquamating rash over face, limbs, trunk, and buttocks. Joint pains and synovitis of the knee and elbow joints are followed by swellings of the long bones, especially the legs. The soles and palms may have fissures and cracks, and condylomata may appear. This stage can last for months or years. In the tertiary stage, the lesions are saber tibia, gummata, gangosa, secondary ulceration giving rise to deep sores with cicatricial contractions, and infection of bones with crippling and disfigurement. The mortality is small. Death is slow and is usually due to starvation after years of pain and disfigurement.

Mass treatment in the field included salvarsan or its derivatives. In primary cases, one injection, in 153 cases, resulted in 136 complete clinical cures, seventeen partial cures; two injections in 101 cases brought ninety-nine complete cures, two partial; and three injections, in forty-eight cases, forty-eight complete cures. In secondary cases, one injection, in 1793 cases, gave 1436 complete cures, 357 partial cures; two injections, in 1280 cases, resulted in 1152 complete cures, 128 partial; and three injections, in 594 cases, 569 complete cures, and twenty-five partial cures. In tertiary cases, one injection, in 3784 cases, resulted in 2834 complete cures, 950 partial cures; two injections, in 2595 cases, brought 2205 complete cures, 390 partial cures; and three injections, in 1012 cases, 912 complete cures, 100 partial cures. Relapses were seen on the way back through the villages treated,—in 30 per cent. of patients receiving one injection, in over 20 per cent. of patients who had had two injections, and in 10 to 15 per cent. in cases receiving three injections.

MANDIBULAR FRACTURES AT KING COUNTY HOSPITAL, TREATED BY ROGER ANDERSON SKELETAL FIXATION. J. Wayne Graham. *Northwest Medicine*, **44**: 250–252, 1945.

Twenty-six cases of mandibular fracture are reviewed. Approximately half were compound fractures, but in only three osteomyelitis developed. Two of these were cases of open reduction, and in the other case a tooth was allowed to remain in the line of fracture. Interdental wiring was done where feasible, but in edentulous cases the Roger Anderson skeletal-pin fixation was used.

The anatomical structures must be carefully studied, and two pins inserted into each fragment, halfway between the lower mandibular border and the alveolar canal. The external maxillary artery and the mental foramen are to be carefully avoided. Intranasal ether vapor is the best anaesthesia.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

SOBRE EL TRATAMIENTO DE LAS FRACTURAS RECIENTES DEL CUELLO DE FÉMUR (Treatment of Recent Fractures of the Femoral Neck). J. Troncoso Rozas. *Revista Española de Cirugía, Traumatología y Ortopedia*, **2**: 213, 1945.

Rozas reviews the progress made in the treatment of fractures of the femoral neck since Sir Astley Cooper divided them into extracapsular and intracapsular fractures. The methods of treatment which he considers are: (1) simple supine rest in bed; (2) continuous traction; (3) immobilization in a large spica (Whitman-Löfberg); (4) early surgical intervention; and (5) continuous extension followed by osteosynthesis at the opportune time. (The latter is the method of election.) Rest in bed, preferably with the femur in abduction, is reserved for fractures in aged individuals with cardiorenal complications, particularly intertrochanteric fractures.

With continuous extension, there is a tendency for irritation of the skin to develop, and external rotation of the femur is common. This method is reserved as a postoperative measure. Traction with a Kirschner wire is more effective than adhesive plaster. The spica of Whitman-Löfberg gives good results in about 50 per cent. of patients under sixty years of age. In regard to immediate operative treatment, ideal conditions are rarely present, and the general condition of the patient is most important. For these reasons there should usually be a period of preparation for the osteosynthesis. In preparation, local anaesthetic at the site of the fracture, and skeletal traction in 30 degrees of abduction, should be used until reduction is obtained. The author prefers this to the method of Leadbetter, and feels that all fractures of the femoral neck, both intracapsular and extracapsular, should be treated by osteosynthesis, with the exception of those few cases in which impaction or interlocking of the fragments prevents movement. In addition, those cases described by Pauwels and Böhler, in which the plane of the fracture is greater than 25 degrees, may be treated conservatively. Contra-indications to osteosynthesis are infancy, fascial hemorrhage, phlebitis, pressure sores, or local infections.

Rozas gives the following end results: Of fifty-eight patients treated conservatively which he was able to follow, twenty showed consolidation with a good anatomical reduction, five showed a moderate coxa vara, twelve had fibrous union, ten had pseudarthroses, and eleven died during treatment. Seventeen patients between the ages of thirty-seven and eighty-two were treated by osteosynthesis and followed from one to ten years. Thirteen were treated by a triflanged nail with excellent results in ten, coxa vara in one, and pseudarthroses in two. Of two treated with cork screw, one obtained a perfect result and one had coxa vara. One patient was treated with Moore pins with a perfect result. (The author does not mention the treatment in the remaining patient treated surgically.)

The author feels that if the fracture is well reduced, the fixation material is non-oxidizable and non-electrolytic, and the osteosynthesis is well performed with good impaction, the results will be uniformly good.—*John G. Kuhns, M.D., Boston, Massachusetts.*

DIFICULTADES EN EL DIAGNÓSTICO PRECOZ DE LA TUBERCULOSIS OSTEOARTICULAR (Difficulties in the Early Diagnosis of Osteoarticular Tuberculosis). Sara Satanowsky. *La Revista de Medicina y Ciencias Afines*, **7**: 445–450, 1945.

The very early diagnosis of tuberculosis of the bones and joints is discussed in detail in this good article. Early diagnosis is difficult and sometimes impossible, as the signs and symptoms are often indistinguishable from those found in arthritis. The early diagnosis is most important, since failure to recognize and treat the disease may have dangerous sequelae; while treating an individual for tuberculosis when he does not have it may cause permanent joint stiffness, as well as a social disturbance to the patient and his family. Johanson has stated that 61 per cent. of patients with osseous tuberculosis have pulmonary involvement; Petter's figure is 85 per cent. Two forms of osteo-articular tuberculosis are found pathologically,—the granular and the caseous.

The roentgenographic examination is of great value in late cases, but in very early cases there are only two suggestive findings: osteoporosis and an alteration (almost always a decrease) in the roentgenographic density of the joint itself. The tuberculin reaction is only occasionally of help. A positive test is of no value, because most people have old pulmonary lesions; a negative test may be a false negative, although this is uncommon. A marked local flare-up of the involved joint is a very suggestive diagnostic sign. The sedimentation rate and blood count are of little or no value. Examination of the joint fluid is most helpful. The presence of tubercle bacilli is diagnostic, but they can seldom be found on direct smear. A positive guinea-pig inoculation is diagnostic. Intraperitoneal inoculation is time-consuming; intraganglion inoculation is better, because a shorter time is required. The organisms can frequently be cultured from the joint fluid in a special medium of Hohn (glycerine and egg) in from eleven to sixteen days. A biopsy of the involved joint is often diagnostic and is frequently indicated.—*Major Louis W. Breck, M.C., Camp Swift, Texas.*

L'ENCLOUAGE MÉDULLAIRE DES FRACTURES DES OS LONGS. MÉTHODE DE KUNTSCHER (Kuntscher's Method of Medullary Nailing of Fractures of Long Bones). G. Laurence. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, **30**: 32, 1944.

Kuntscher reported in 1939 and also in 1940 on the technique and preliminary results of his medullary nailing of fractures.

The advantages are as follows:

1. Solid fixation of the fracture with early mobilization of the limb.
2. Osteosynthesis with opening of the fracture site.
3. Creation of biological and mechanical conditions most favorable for speedy formation of callus with a minimum of apparatus.

To overcome the disadvantage of using voluminous metal for fixation, which acts as a foreign body, the rod was triflanged or biflanged, and was made of special steel called V2A.

Experimentally, the method proved satisfactory. Many successful clinical results were reported.

Rigid rods were used for the femur and the ulna; flexible rods which could be made rigid, once introduced into the bone, were used for other bones. The introduction of the rod could be done under roentgenographic control.

For satisfactory fixation, the distal fragment has been engaged for at least five centimeters. If closed reduction is impossible, the fracture site has to be exposed.

The patient is permitted out of bed in from eight days to three weeks after the introduction of the rod. The rod may be removed after consolidation, in from twelve to eighteen months.

The method may be used in any age group, for a variety of fractures, including pathological fractures, and also in pseudarthrosis.

Apparently a number of complications were observed by surgeons, but the opposition, which was strong when the method was introduced, has subsided with subsequent reports.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

ÉVOLUTION A LONGUE ÉCHÉANCE DE L'OSTÉOCHONDRITE DE LA HANCHE. INFLUENCE DU TRAITEMENT SUR LA QUALITÉ DU RÉSULTAT (Late Evolution of Osteochondritis of the Hip. Influence of Treatment on the Results). L. Tavernier et J. Mallah. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* **30**: 65, 1944.

The authors analyzed the late results in a group of twenty-five patients, examined from nine to twenty-five years after the onset of osteochondritis. The present article includes only a roentgenographic study of the development of the affliction.

Several cases were observed in the very early stages. At the onset of pain in the hip, no changes were observed by roentgenogram. Only after several weeks was a widening of the epiphyseal plate observed. Subsequently the typical picture of osteochondritis appeared.

The authors describe two types of deformity: The well-known mushroom type starts with a widening of the epiphyseal plate, followed by reduction in size and condensation of the epiphyseal nucleus, and finally by a modification of the neck; this was observed in eighteen patients. The angulated type, in which the head becomes triangular in shape, was seen only five times, and differs so much from the mushroom type that it could be taken for a different entity, were it not for the intermediary roentgenograms.

In two cases there was complete restitution of the femoral heads with early mushrooming. These patients were subjected to strict immobilization for one and two years, respectively.

Functionally, these two patients with complete restitution of the heads were normal. Of the eighteen patients with mushroomed heads, two had a perfect functional result.

A second group of nine patients with good function was observed, seven of whom had a mushroom deformity and two an angular deformity of the head. These patients had no pain or limp, and only slight limitation of motion.

A third group of nine patients with only satisfactory results also included seven with the mushroom deformity and two with the angular deformity.

Of the twenty-five patients, three were severely disabled. Two of them showed a mushroom deformity and one an angular deformity. The roentgenograms showed advanced arthritis.

The authors believe that roentgenographic evidence of deformity is compatible with good function.

In 50 per cent. of good results, only 8 per cent. showed complete roentgenographic restitution. Twelve per cent. had unsatisfactory function, with severe arthritis. The authors believe that prolonged immobilization may produce anatomical and functional restitution, while abortive treatment leads to a severe deformity and arthritis in 12 per cent. of the patients.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

TRAITEMENT PAR LES INFILTRATIONS SYMPATHIQUES DES TROUBLES RÉFLEXES POSTTRAUMATIQUES, DITS PHYSIOPATHIQUES (Treatment of the Posttraumatic Reflex Disturbances Known as the Physiopathic Syndrome). G. Arnulf. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* **30**: 161, 1944.

The author describes a method of treatment of the troublesome posttraumatic disturbances observed after injuries to the extremities, characterized by atrophy, vasomotor changes, oedema, changes in the appearance of the skin and nails, and osteoporosis.

Citing the infiltration of the sympathetic ganglia originated by other surgeons, the author recommends the following procedure:

1. The stellate or the lumbar ganglia must be infiltrated, according to the involvement of the upper or lower extremity.
2. Large doses of novocaine (twenty cubic centimeters) must be used for injections.
3. The infiltration must be repeated ten or fifteen times every three days in the beginning, and once a week thereafter.

4. Immediately after the injection, when vasodilatation is obtained, the involved extremity must be "worked" by light passive motions, followed by active use of the wrist and fingers.

5. It is useful to infiltrate locally the wrist or fingers for increased mobilization of stiffened joints.

The patient's interest should be evoked in the comprehension of the treatment, and in appreciation that each infiltration is only a step in the general improvement.

The number of infiltrations may be lessened by early treatment. The author cites a case in which one infiltration was sufficient to produce recovery.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

CARPAL BONE INJURIES. John D. Sherrill. *Southern Medical Journal,* **38**: 306–312, 1945.

Sherrill reviews injuries to the small bones of the wrist. Fresh fractures of the carpal scaphoid are treated by prolonged immobilization in a plaster cast to the wrist, including the thumb; the wrist is in radical deviation and 30 degrees of dorsal flexion. At least four months should pass before a diagnosis of non-union is made. Cases diagnosed as late as three or four weeks after injury should be treated as fresh fractures. In the treatment of non-union, the following methods have been advocated: immobilization, drilling, bone-grafting, excision of one or more fragments or of the entire bone, and fusion of the wrist joint. Several cases of persistent non-union have been seen, which have had few disabling symptoms. Cases should be carefully studied before surgery is decided upon.

In dislocation of the semilunar, an attempt at closed reduction under anaesthesia should be made. If not successful, open operation is done and the bone is replaced or excised. Other fractures and dislocations of the carpal bones are discussed.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

COLLES' FRACTURE. J. Warren White. *Southern Medical Journal,* **38**: 415–417, 1945.

In cases of Colles's fracture, the author advocates complete reduction under a general anaesthetic, check by roentgenogram, and maintenance of the hand and wrist in pronation and ulnar deviation (Cotton and Loder position) in a plaster cast from metatarsal heads to mid-humerus. After two or three weeks the position of the hand may be changed, and the cast shortened. Splints, either home-made or custom-made, are not so satisfactory as plaster casts. The plaster should not be removed for five or six weeks.

The conclusions are as follows: (1) Do not attempt reduction without roentgenograms. (2) Use a general anaesthetic. (3) Secure anatomical reduction. (4) Use plaster casts, but not splints. (5) Do not remove the cast too soon. (6) Have the patient move the fingers. (7) Do not use physiotherapy too strenuously. (8) Do not resort to subsequent surgery in older people.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE USE OF SKIN FLAPS IN THE REPAIR OF SCARRED OR ULCERATIVE DEFECTS OVER BONE AND TENDONS. Earl C. Padgett and John H. Gaskins. *Surgery,* **18**: 287–298, 1945.

The authors report a series of ninety-seven patients treated for deep adherent scars, many of them over bones or tendons, by means of thick skin flaps. In many instances, the entire operation was carried out in one procedure, thereby reducing the period of hospitalization to approximately one-fifth that required in procedures making use of delayed or tube flaps.—*Edward L. Compere, M.D., Chicago, Illinois.*

HUMAN FIBRIN FOAM WITH THROMBIN AS A HEMOSTATIC AGENT IN GENERAL SURGERY. EXPERIMENTAL STUDIES AND CLINICAL USE. Orville T. Bailey, Franc D. Ingraham, Orvar Swenson, John J. Lowrey, and Edgar A. Bering, Jr. *Surgery,* **18**: 347–369, 1945.

Fibrin foam, a material obtained in the fractionation of human blood plasma for the preparation of human fibrinogen and thrombin, is an effective absorbable hemostatic agent when soaked in human thrombin solution. This material will control bleeding from oozing surfaces, from the dural sinuses, and even from large cerebral veins.

The authors emphasize, however, that the use of fibrin foam with thrombin should not replace the careful control of bleeding by means of meticulous dissection and adequate placing of sutures.—*Edward L. Compere, M.D., Chicago, Illinois.*

PULMONARY EMBOLISM IN FRACTURES OF THE HIP. Harry Golodner, Louis J. Morse, and Alfred Angrist. *Surgery,* **18**: 418–423, 1945.

Heart disease and bronchopneumonia have been thought to be the most common causes of death, following fractures of the hip. Pulmonary embolism has not been considered as often as this article would indicate that it should be. Of 304 patients who were treated for intertrochanteric or intracapsular fractures of the neck of the femur, there were eighty-six deaths. Twenty-five autopsies were performed, and the causes of death in these patients were as follows: pulmonary embolism in nine, bron-

chopneumonia in seven, arteriosclerotic heart disease in four, and miscellaneous causes of death, including sepsis, in five.

This study would indicate that pulmonary embolism from venous thrombosis in the veins of the lower extremities is the most frequent cause of death in cases of fracture of the hip. From their observations, the authors conclude also that this complication is less frequent in patients who become ambulatory early. They have suggested prophylactic bilateral ligation of the superficial femoral vein, combined with lumbar sympathetic block, for the prevention of pulmonary embolism in fractures of the hip of patients who cannot be made ambulatory early.—*Edward L. Compere, M.D., Chicago, Illinois.*

THE TREATMENT OF PROGRESSIVE BACTERIAL SYNERGISTIC GANGRENE WITH PENICILLIN. Frank L. Meleney, Sidney T. Friedman, and Harold D. Harvey. *Surgery*, **18**: 423–435, 1945.

Treatment of three cases of progressive bacterial gangrene, one of the chest wall, a second of the abdominal wall, and the third of multiple lesions involving areas of both legs and the chest, was reported. The organisms found in the cultures were of numerous bacterial species. In the first two patients, the spread of the gangrenous infection was checked by penicillin. Response to this therapy in the third patient was very slight. Surgical excision was attempted but the patient died on the morning of the seventh postoperative day from a large pulmonary embolism.

The authors conclude that the presence of *Escherichia coli* and *Pseudomonas pyocyanea* in the infected gangrenous areas of Case No. 3 were responsible for the failure of penicillin in the treatment of this patient. They demonstrated in the laboratory that these organisms elaborated penicillinase, which completely inactivated penicillin *in vitro*. They conclude, however, that penicillin should be tried in all patients with bacterial progressive gangrene.—*Edward L. Compere, M.D., Chicago, Illinois.*

THREE HUNDRED FIFTY-TWO CASES OF TETANUS. Roald T. Vinnard. *Surgery*, **18**: 482–492, 1945.

In most areas within the United States, tetanus has become an extremely rare disease. A report of 352 patients treated in the Charity Hospital of Louisiana at New Orleans in a single ten-year period represents a series which is large enough to constitute a scientific study. The total mortality was 45 per cent. Vinnard urges routine immunization by tetanus toxoid of the entire population; routine administration of prophylactic antiserum in the treatment of all injuries of patients who have not previously received toxoid immunization; and education of the lay public to report, and of doctors to recognize and institute immediate therapy for, symptoms of early tetanus.

The above recommendations are for the purpose of preventing tetanus. The program of treatment, where tetanus has already appeared, was also discussed. Perhaps it would be well to add that early and complete débridement and cleansing of all wounds for the removal of dirt and other foreign material would be an additional safeguard against tetanus, as well as against other infecting organisms.—*Edward L. Compere, M.D., Chicago, Illinois.*

GUNSHOT FRACTURES OF THE SHAFT OF THE HUMERUS. William T. Fitts, Jr., Charles K. Kirby, and Ernest A. Brav. *Surgery*, **18**: 493–497, 1945.

Gunshot fractures of the shaft of the humerus comprised approximately 3 per cent. of all battle casualties among the patients who were admitted to the general hospital from which this study was made. The hanging arm cast was used in treating the majority of these fractures, and bone union was accomplished in almost every instance in which there was no significant bone loss. Ninety-three per cent. of the wounds were débrided in forward hospitals. Débridement was performed within the first twelve hours in 69 per cent. of all the injured. Sulfanilamide was used locally in every wound, and oral sulfonamides were given to all patients before admission to the hospital.

Most of the patients arrived at the hospital wearing abduction plaster spica casts. In the majority, there was marked disalignment of the fractures, which corrected immediately after the spica was removed and the arm was permitted to drop to the side in a hanging cast. Associated nerve injuries occurred in many of these fractures and were the most frequent cause of permanent disability.—*Edward L. Compere, M.D., Chicago, Illinois.*

STUDIES IN EXPERIMENTAL VASCULAR SURGERY. Sidney Smith. *Surgery*, **18**: 627–643, 1945.

A very complete review of the literature, including a history of vascular surgery, is included in this report. Using dogs for experimentation, numerous techniques previously described were repeated under controlled conditions. The use of a soluble rod inserted into the cut ends of an artery was found to be a very readily applicable method of approximating accurately the edges of arteries while they were being sutured. This rod went into solution in the pulsating blood in one minute or less. The arterial sheath was then sutured securely all the way around the artery at the site of the anastomosis.—*Edward L. Compere, M.D., Chicago, Illinois.*

ORTHOPAEDIC SURGERY FOLLOWING PERIPHERAL-NERVE INJURIES. V. D. Chaklin. *Voprosi Neurokhirurgyi*, No. 3, 50, 1944.

There are areas of nerve injuries, where all attempts at repair will be useless. There are other areas in which nerve suture gives mediocre results after long convalescence.

In the upper extremity, in the presence of grave injuries to the brachial plexus, the treatment consists in: (1) operative correction through an osteotomized clavicle with special attempt to repair the median nerve; (2) support of the extremity with a hinge joint for the elbow; (3) arthrodesis of the shoulder after a period of eight to ten months, followed by immobilization for three months; (4) muscle transplantation for extension, if flexion of the wrist and fingers has been restored. In the presence of total paralysis of all the muscles of the upper extremity, arthrodesis of the shoulder and the elbow with a tenodesis of the wrist is advisable. Radial-nerve paralysis may require either transplantation of tendons or a combined suture of the nerve with transplantation of tendons. For median-nerve paralysis involving the thenar muscles, one of Bunnell's procedures is recommended.

In the lower extremity, injuries to the femoral nerve involving the quadriceps present difficult problems. Contractures of the knee joint have to be overcome and then transplantation of the biceps performed; or combined transplantations of the tensor fasciae latae and sartorius may be advisable. Among the less desirable corrective measures are arthrodesis and arthroereisis of the knee joint.

Injuries to the sciatic nerve require prolonged physiotherapy, the wearing of light braces, and tenodesis of the extensor tendons or posterior arthroereisis of the ankle. Special attention should be given to the often overlooked contracture of the toes.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

CAMPTOCORMIA. A FUNCTIONAL CONDITION OF THE BACK IN NEUROTIC SOLDIERS. S. A. Sandler. *War Medicine*, **8**: 36, 1945.

No doubt very few of our orthopaedic colleagues are familiar with the term "camptocormia". The author defines this as a "hysterical phenomenon seen during wartime in certain neurotically ill soldiers". The condition is manifested by pain in the lumbar area and by a marked flexion of the trunk. It may or may not be precipitated by trauma. Primarily it is functional in origin.

Sandler presents a long series of case reports on soldiers, some of whom have had attacks prior to entering the Army. These patients are never erect, but when standing or walking bend forward at an angle of from 60 to 90 degrees. Most of them had either adored or hated their fathers; thus the father-son complex was developed to a rather extreme degree. The fathers of many also had complained of pain in the back throughout the span of memory of the patient.

A few of the patients were cured by psychotherapy. Strangely, in almost every case the back-bending phenomenon was attended, or had been preceded, by sexual impotence. Sandler expresses the opinion that many of these patients were at least potential homosexuals.

Whether in military or civilian life, these patients are usually incorrectly diagnosed and considered to be malingerers. The orthopaedic surgeon who sees such a patient should try to obtain a neuropsychiatric history and, when the correct diagnosis has been made, refer the patient to a psychiatrist if possible.—*Edward L. Compere, M.D., Chicago, Illinois.*

MADURA FOOT. F. E. Clough. *The Western Journal of Surgery, Obstetrics and Gynecology*, **53**: 153, 1945.

Madura foot is usually considered a rare tropical disease indigenous to India, but forty-three cases have been reported in the United States and Canada and four unpublished cases, originating in California, were discussed in 1944. This term includes "all fungoid diseases of the feet in which there is grain formation, regardless of fungous etiology". There are at least forty-eight species of fungi that might cause the disease, and many of these belong to the family of *Actinomyces*. All species give rise to the same symptoms, pathological changes, and end results. They all produce grains or seeds of various colors as their distinguishing features.

A case is reported of a forty-three-year-old Mexican agricultural worker who was first seen in 1930, because of discomfort in his left foot. In 1934 he was given corrective foot pads. Roentgenograms at that time showed no bone changes. In 1936 the foot began to swell and roentgenograms showed several tiny drill holes through the fourth metatarsal. Several small sores had broken open and healed. On March 8, 1940, the entire foot was greatly swollen. The skin was thick and darkened. Nodules, varying in size from a small shot to a marble, could be felt everywhere. Sinuses were excreting a thin, yellowish pus from which could be expressed tiny brownish seeds. Fungi were found in the crushed seed. Pain was not a major complaint. Roentgenograms showed a worm-eaten appearance of all the metatarsals and tarsals; the contour of the bones remained normal, but one metatarsophalangeal joint showed beginning destruction. All types of medication were tried with no benefit. In February 1942 the left foot was amputated. Recovery was uneventful.—*Commander F. Harold Downing, U.S.N.H., Shoemaker, California.*